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This FY87 TOD details the Directorate of Engineering and Services Laboratory (HQ AFESC/RD) research and development program in civil engineering and environmental quality. The programs are directed toward expanding the technology base needed for developing state-of-the-art capabilities to support the wartime Engineering and Services' role in projection of aerospace power. These efforts encompass activities in the areas of facility systems, pavements, and fire technology. In addition, environmental research is pursued to assure that compliance with material environmental regulations will not impede Air Force operations.

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PREFACE

This technical report sets forth technical objectives for civil engineering (CE) and environmental engineering (EE) research and development (R&D) conducted by the Headquarters Air Force Engineering and Services Center, Engineering and Services Laboratory (HQ AFESC/RD), Tyndall Air Force Base, Florida 32403-6001. This information is designed to provide other laboratories, industry, and the academic community with preliminary necessary information on this Laboratory's planned technology programs. Project officer for these programs is John D. Martel, HQ AFESC/RDXP.

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This document has been reviewed and is approved for publication.

LAWRENCE D. HOKANSON, Colonel, USAF
Director of Engineering and Services Laboratory

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SECTION I

INTRODUCTION

The Air Force TOD program is an integral part of the process by which the Air Force plans and formulates a detailed technology program to support the development and acquisition of Air Force weapons systems. Each Air Force laboratory annually prepares a research and technology (R&T) plan in response to available guidance based on USAF requirements, the identification of scientific and technological opportunities, and the needs of present and projected systems. These plans include proposed efforts to achieve desired capabilities, to resolve known technical problems, and to capitalize on new technical opportunities. The proposed efforts undergo a lengthy program formulation and review process. Generally, the criteria applied during the formulation and review are responsiveness to stated objectives and known requirements, scientific content and merit, program balance, developmental and life cycle costs, and consideration of payoff versus risk.

It is fully recognized that the development and accomplishment of the Air Force technical program is a product of teamwork on the part of the Air Force laboratories and the industrial and academic research and development (R&D) community. The TOD program is designed to provide industry and the academic community with necessary information on the Air Force laboratories' planned technology programs. Each laboratory's TOD is extracted from its R&T plan.

Specific objectives are:

1. To provide planning information for independent R&D programs.

2. To improve the quality of the unsolicited proposals (UP) and R&D procurements.

3. To encourage face-to-face discussions between nonGovernment scientists and engineers (S&E) and their Air Force counterparts.

One or more TODs have been prepared by each Air Force laboratory that has responsibility for a portion of the Air Force's technical programs. Classified TODs are available from the Defense Documentation Center (DDC), and unclassified TODs are available from the National Technical Information Service (NTIS).

SECTION II

HOW TO USE THIS DOCUMENT

Unsolicited proposals (UPs) to conduct programs leading to the attainment of any of the objectives presented in this document may be submitted directly to an Air Force laboratory. However, before submitting a formal proposal, we encourage you to discuss your approach with the laboratory point of contact. After your discussion or correspondence with the laboratory personnel, you will be better prepared to write your proposal.

As stated in the "AFSC Guide for UPs" (copies of this informative guide on UPs are available by writing to Headquarters Air Force Systems Command (HQ AFSC/PPPR, Andrews AFB DC 20334)), elaborate brochures or presentations are definitely not desired. The "ABCs" of successful proposals are accuracy, brevity, and clarity. It is extremely important that your letter be prepared to encourage its reading, to facilitate its understanding, and to impart an appreciation of the ideas you desire to convey. Specifically, your letter should include the following:

1. Name and address of your organization.

2. Type of organization (profit, nonprofit).

3. Concise title and abstract of the proposed research, and the statement indicating that the submission is a UP.

4. An outline and discussion of the purpose of the research, the method of attack, and the nature of the expected results.

5. Name and research experience of the principal investigator.

6. A suggestion as to the proposed starting and completion dates.

7. An outline of the proposed budget, including information on equipment, facility, and personnel requirements.

8. Names of any other Federal agencies receiving the proposal (this is extremely important).

9. Brief description of your facilities, particularly those which would be used in your proposed research effort.

10. Brief outline of your previous work and experience in the field.

11. If available, a descriptive brochure and a financial statement.

As you read through the pages that follow, you may see a field of endeavor where your organization can contribute to the achievement of a specific technical goal. If such is the case, you are invited to discuss the objective further with the S&E identified with that objective. Further, you may have new ideas not considered in this document which, if brought to the attention of the proper organization, can make a significant contribution to our military technology. We will always maintain an open mind in evaluating any new concepts which, when successfully pursued, would improve our future operational capability.

On behalf of the United States Air Force (USAF), you are invited to study the objectives listed in this document and to discuss them with the responsible Air Force personnel. Your ideas and proposals, whether in response to the TODs or not, are most welcome.

SECTION III

MANAGEMENT OVERVIEW

A. LABORATORY MISSION

1. The Air Force Engineering and Services Center Laboratory (AFESC/RD) mission is derived from the engineering and services (E&S) mission, as well as that of the Headquarters Air Force Systems Command (HQ AFSC). The E&S mission is to provide the necessary assets and skilled manpower to prepare and sustain worldwide installations as stationary platforms for projection of aerospace power in peace and war.

2. The HQ AFSC mission is to advance aerospace technology and apply it to aerospace systems development/improvement, and to acquire superior, cost-effective, supportable aerospace systems and equipment.

3. RD must plan and execute USAF basic research, exploratory development, advanced development, and selected research and engineering development programs to support E&S's operational missions in airbase performance and Air Force projection and employment of air power. RD is tasked with developing and providing the technology base for the tools and training of the military engineer which must be as much "state of the art" as the weapons systems he supports.

4. Principal elements of this mission include:

a. Achieving and maintaining superiority in R&D areas required to support the E&S operational mission.

b. Establishing and effectively applying laboratory capabilities to prevent technological surprises.

c. Identifying improvements that meet near- and/or long-term needs of the military engineer in support of aerospace forces.

d. Providing technical support to operational and logistics commands.

B. INVESTMENT STRATEGY

1. Our investment of R&D resources is guided by our goal of providing state-of-the-art capabilities to the E&S forces in the achievement of their wartime mission. The definition of technical requirements associated with that mission is continuing to evolve into a more structured and effective

process. ~~In the past~~, our investment approach has been motivated by statements of operational need (SON), logistics needs (LNs), public law, and Air Force planning documents (Vanguard and Forecast II). In addition, our investment goals were reviewed and guided by the Engineering and Services Requirements Board (ESRB), composed of the director of E&S and major command (MAJCOM) deputy chiefs of staff. When fully institutionalized, this process will identify E&S-required capability to support all Air Force operational missions against any threat anywhere in the world. Once E&S-required capability is identified, the process will allow RD to compare E&S current and future capability to required capability resulting in needs identification. Once these needs are identified, RD can then proceed on developing the required tech base and selected engineering development programs to address these identified needs. The E&S requirements identification process will play a key role in the development of future investment strategies of this laboratory. In the future, this investment for E&S guidance will be supplemented by the results of an E&S requirements identification process being established within the E&S communities during FY 87.

2. Current emphasis in the laboratory R&D program is placed on deriving the technologies to support advancements in the areas of airbase operability (ABO), including mission-essential facilities, launch and recovery platforms, survivable utilities, fire protection and recovery, and environmental quality assessments and pollution control

3. The payoff of these R&D activities is improved readiness of our operational forces and decreased impact of national environmental regulatory requirements on Air Force peacetime operations. Our facilities survivability and postattack airbase recovery efforts will provide advanced materials, equipment, and techniques to increase the Air Force's wartime sortie generation capability. Our environmental quality (EQ) efforts will provide the Air Force with the technology required to comply with federal and state environmental regulations, while conducting training and tactical missions, operating its support facilities, and developing, producing, and deploying new weapon systems.

C. DIRECTOR'S ASSESSMENT

1. A special study of the E&S mission area performed by an Ad Hoc Committee of the Air Force Scientific Advisory Board (SAB) in 1983-84 found a serious imbalance between Air Force investments in weapons system technology and technological investments to assure adequate airbase operability. The Ad Hoc Committee identified the need for a stronger R&T program to keep airbase-support capabilities on a comparable readiness basis with the weapon systems they support. The results of these intensive studies have allowed this laboratory to better understand its capabilities, limitations, and challenges. The studies confirmed the importance of the laboratory's role in developing and sustaining an adequate technology base to assure the effectiveness of E&S forces in their critical role in the projection and employment of air power.

2. Over the next 5 years, our program will have significant impact on the ability to achieve the goals established by the Ad Hoc Committee. Our resources will be directed toward building a strong technology base in the facilities system and analysis, airfield pavement, and fire protection and control areas. The Defense Environmental Restoration Program (DERP) will dominate the technological and engineering development activities of our environmental quality program over the upcoming 5-year period.

D. ORGANIZATION AND MANAGEMENT

1. Research and Development (RD) is part of the HQ AFESC located at Tyndall AFB FL. The director of the laboratory reports directly to the Commander of AFESC, and to the Deputy Chief of Staff for Science and Technology at Headquarters Air Force Systems Command (HQ AFSC/DL), Andrews Air Force Base, Maryland 20334. Operations and maintenance funds are provided by the Air Staff through the Center, while R&D funds and program management direction are provided by HQ AFSC/DL.

2. This Laboratory has been organized to respond to the Air Force E&S' needs. The organization is structured to implement basic research, exploratory development, advanced development, and full-scale development in the areas of fire protection, facilities, utilities, aircraft operational surfaces, hazardous waste, and Air Force fuels and chemicals. The organizational chart for the laboratory reflects these technical areas.

E. FUNDS

The laboratory manages approximately $20 million annually. All our funds are used to obtain the expertise and capabilities of universities, industry, and other Government agencies in the development of Civil Engineering and Environmental Quality technology. These funds support basic research, exploratory development, advanced development, and full-scale development programs, and include funds provided by other Government agencies desiring support in these areas.

F. MANPOWER

The laboratory consists of approximately 107 assigned military and civilian scientific, engineering, administrative, and support personnel with approximately 60 percent in the S&E category covering the full range of disciplines relevant to E&S. The high level of educational attainment of professionals is reflected by over 17 percent with doctorate degrees and 50 percent with masters degrees. In addition to these, we have approximately 23 scientific, engineering, and support personnel who support the laboratory primarily in the areas of plans, programs, and financial management.

G. FACILITIES

The Engineering and Services Laboratory is co-located with the HQ AFESC. Our Engineering Research Division is located in the same building as the Center. We have recently moved our Environics Division into a new $3.5 million laboratory, built adjacent to the Center. This new facility provides more than 33,000 square feet of floor space in an atmosphere as modern, functional and efficient as our Center itself, combining our formerly separate laboratory facilities under one roof, and also providing room for an expanding mission, not only for engineering, but for services as well.

We are building small-scale models of shelters, facilities, and equipment for experiments in survivability against conventional weapons attacks, saving not only the money now spent for full-scale construction, but a considerable amount of time as well.

Engineering research will be accelerated even further by the recent installation of a small centrifuge, and a larger one planned for FY 90. These centrifuges allow gravity and time-dependent events to be accomplished at a very small scale, and compress years of effects into only a few hours. In dynamic events, stress factors of explosions can be obtained without the usual dangers and expense of present large-scale demolition methods.

H. SUMMARY

The following sections project the direction of our R&D activities for the next 5 years. Technologies, subtechnologies, and benefits to the Air Force are explained in Sections IV and V. The projections are based on needs identified in Air Force requirements and guidance documents, as well as on technology deficiencies projected by the scientific community. For this reason, they are under constant review and revision to assure optimization of R&D resources. Road maps for each major thrust are provided in Appendices A through E.

SECTION IV

CIVIL ENGINEERING TECHNOLOGY PROGRAM

A. FIRE PROTECTION

1. The Fire Technology Branch (RDCF) plans, manages, and conducts fire protection programs that advance state-of-the-art technology in prevention, detection, and suppression of fire (to include rescue from aircraft and structural facilities); provide technical expertise for development of specifications and design criteria for protection of high-value inventory/ facilities; manages in-house and contractual research projects and resolves conflicting fire technology issues; determines the technical approach, methodology and scope of research required for resolution of the fire problem and operational requirements; serves as a technical authority/ consultant to DOD and other agencies conducting research, development, test and evaluation projects for crash rescue, firefighting, equipment, agents, and training; interfaces with industrial, institutional and Government research organizations on technology advancements and findings related to fire protection; and serves as program manager for development of new fire equipment, agents, suppression techniques and systems to support aircraft fire/structural/crash rescue crews worldwide.

2. Major technologies within this branch include:

a. Enhanced agents,

b. Advanced equipment and vehicles,

c. Fire assessment capability, and

d. Understanding physics of fire.

3. ENHANCED AGENTS:

a. This technology is directed by the Planning Input for Program Development (PIPD) which directs improving recovery capability after airbase attack and the results of SALTY DEMO which highlighted problems in Air Force firefighting capability.

b. To address these problems, RD has initiated programs to improve existing agents such as AFFF and Halon 2402, and to develop a new family of agents for hydrazine and magnesium. We are also developing the tech base for a new generation of agents to address new fuel and materials identified in Project Forecast II.

c. The payoff to the Air Force is improvement in current fire fighting capability. Our program also addresses potential future weapon systems. Development of the tech base will provide the necessary information to develop new agents to enhance Air Force fire fighting capability for supporting advanced weapon systems when they reach initial operational capability (IOC).

4. ADVANCED EQUIPMENT AND VEHICLES:

a. The need for mobile equipment for bare base operations, operation in a chemical/biological environment, and protection of high value Air Force property drives this major thrust. These needs were derived from various statements of need (SON) for postattack launch and recovery, and improving firefighting capability. In addition, the PIPD, SALTY DEMO, and AFSC Vanguard plans point out a need for improving postattack recovery capability.

b. To address the need for mobile equipment, we are pursuing programs for improving rescue vehicles, turret systems, vehicle hardening, current dispensers, and developing new dispensing concepts. Programs to improve firefighting ensembles, developing next-generation ensembles, and survivable collection protection shelter (SCPS) address the need to operate in a chemical/biological environment. Protection of high-value Air Force property is being addressed with robotic fire sentries for both facilities and large-body aircraft, fire protection for aircraft in shelters and hot pit refueling, and remote control of firefighting equipment.

c. Payoffs to the Air Force include improved operational capability through protection of high-value assets, and improved fire fighting capability in a chemical/biological and post attack environment.

5. FIRE ASSESSMENT CAPABILITY:

a. The best way to fight fires is to prevent them in the first place. If this fails, then the firefighter needs to be able to set priorities in the case of multiple fires and efficiently respond to fires when the priorities have been met. The need for assessing hazards in support of weapon systems design, the need for an active/passive mix, and improved response to fires drives this technology.

b. A design assessment system and thermal tank assessment address the need for supporting weapon system design. Postattack assessment is a tool which will be used to determine an optimum active/passive mix. A response data system will aid the firefighter in determining the most efficient way to attack a fire.

c. These programs are designed to improve fire suppression capability and increase postattack resource recovery.

6. Understanding physics of fire:

a. This technological area is driven mainly by the development of new fuels, chemicals, and materials identified by Project Forecast II. These new fuels, chemicals, and materials are slated for future Air Force weapon systems which will require fire protection.

b. Our programs are aimed at understanding the physics of fire, computer modeling of fire phenomenon, and determining the effects of munitions, composite material and fuel in fire.

c. The payoff of this tech base effort will be the necessary knowledge for developing new agents, dispensers, vehicles, and equipment in support of advanced Air Force weapon systems.

B. FACILITY SYSTEMS AND ANALYSIS

1. The Facility Systems and Analysis Branch (RDCS) plans, manages, and conducts RDT&E programs to support a full spectrum of Air Force Civil Engineering requirements, worldwide. This involves RDT&E programs to: increase survivability of key airbase facilities/functions in situations of enemy attack with nonnuclear weapons; improve tactical mobility shelters and associated systems of relocatable facilities; improve airbase chemical/ biological warfare defense and passive defense techniques; survivability/ reliability of utility systems; serve as the Air Force focal point for facilities energy R&D; and provide limited technical consultation and assistance, resources permitting, and expertise for above resource areas.

2. Major technologies within this branch include:

a. Survivable facilities,

b. Survivable utilities,

c. Facility recovery,

d. Physical security,

e. Mobility facilities and equipment, and

f. Base Civil Engineer (BCE) productivity.

3. SURVIVABLE FACILITIES:

a. The airbase is an integral part of the Air Force's ability to wage war. It must function effectively at all times or the aircraft weapons systems cannot perform. Critical facilities must be both resistant to damage and easily repaired if they are damaged. Survivability can be

enhanced through a wide range of techniques ranging from physically hardening fixed facilities against weapons effects through dispersal to avoid attack. Varying levels of blast, fragment, and CB protection are normally specified based on affordability and criticality. Opportunities to continue to apply new materials and design techniques must be exploited for improved survivability of combat bases at more affordable cost.

b. Subtechnology:

(1) Advanced-hardened structures criteria

(2) Semihardened facilities protection development

(3) Protective overlays for facilities

(4) Modular facilities

(5) Facility upgrades

(6) Material and methods

c. The payoff to the Air Force is improved mission performance. As critical facilities become harder and more resilient, Air Force capability to carry out operational missions will continue to improve. Economical techniques will also spread the benefits of improved survivability to the maximum number of facilities.

4. SURVIVABLE UTILITIES:

a. Utilities and land-line communications are the arteries and nerves which give life to airbase facilities. Critical operational functions cease immediately without electric power and can only continue for short periods without water. Loss of land-line communications quickly overloads wireless systems and POL trucks are rarely able to replace pipelines for extended periods. Emergency power generators and distributed storage facilities for water and POL can ease the immediate impact of system outage, but they all increase demands for manpower and other support equipment if the disruption lasts more than a few hours. Distribution systems will never be invulnerable, but the effects of outages can be minimized and managed through redundancy, fault isolation, and rapid repair. The extent of utilities infrastructure at combat bases requires that investments in redundancy be low cost for affordability. Rapid fault isolation and repair depend on accurate system status information and reliable schematics of lines, valves, switches, etc. Current systems have, in general, been designed to minimize construction cost, are usually not accurately recorded on system drawings, and do not lend themselves to timely status analysis.

b. Subtechnology:

(1) Hardened distribution system design criteria

(2) Low-cost techniques for redundancy

(3) Advanced power production

(4) Alternate fuels

c. More resilient utilities systems allow the operational missions to continue with minimum hindrance and relieve some of the load on repair personnel during crisis operations.

5. FACILITY RECOVERY:

a. The critical first step in recovering after an attack is to know the kinds of damage inflicted, and understand how each damaged facility will affect operational performance. Extensive effort has been devoted to assessing damage to paved airfield surfaces, but relatively little attention has been directed toward assessing facility and utility damage. Damage assessment has several components. The BRAAT must: (1) quickly locate damage; (2) understand the importance of the facility or utility to operational performance; (3) evaluate the criticality of the damage to continued operations use; and (4) dispatch the right personnel, equipment, and materials in the correct order of priority. The BCE must be able to integrate damage-assessment data, priorities, and resources with little reference to high authority for guidance, and with confidence that his decisions are consistent with the operational commander's needs. R&D is needed to improve damage-assessment survey techniques to ensure that meaningful data is recognized and reported accurately. Better systems are also needed to evaluate the severity of damage to the continued use of the facility, and the difficulty of recovery. Large-scale exercises to refine skills in damage assessment and recovery are conducted infrequently because of expense and difficulty in preparing them. BRAAT personnel must have realistic training mechanisms which allow them to exercise realistically between exercises.

b. Once damage assessment of critical facilities and utilities has been accomplished, they must be quickly returned to service following an attack. Repairs must provide adequate interim operating capability with minimum investment in personnel and equipment. This is a different mode of operation than repair crews are trained to handle in peacetime. Crisis repair techniques require different kinds of materials, are done to a lower finish standard, and must often be done with minimal or no equipment support. Storage distribution plans must also ensure that materials are widely distributed to preclude total destruction. Distributed storage generates a need for accurate responsive inventory tracking systems so that

materials can be found and moved to repair sites. Expedient C/B decontamination techniques must also be integrated into repair training.

c. Subtechnology:

(1) Damage assessment facilities/utilities

(2) Methods and materials

(3) Information system for crisis operations

(4) Training

d. The proficiency of the civil engineer to recover the airbase after an attack has a direct impact on sortie generation. Better techniques and systems will enhance recovery, and effective training tools are the key to ensuring that those techniques and systems will be properly applied when needed. Training simulators will also make field exercises more productive. Improvements in repair response time and efficient allocation of personnel, equipment, and materials result directly in improved facilities and utilities operational capabilities.

6. PHYSICAL SECURITY:

a. All military facilities are continuously subject to the threat of intrusion for purposes of theft, espionage, or sabotage. Theft and espionage are covert activities which the intruder attempts to complete without detection. Sabotage by commandos or terrorists is destructive, and is carried out for interdiction or publicity. While the ends are different, many of the means for protection against these threats are similar. In each case, effective security depends upon physical hardening, guard forces, and intrusion detection systems. The Air Force must provide adequate physical security for all installations at affordable cost. However, there are wide variations in security needs depending upon criticality of function and perceived threat. Special attention is currently being focused on preventing/mitigating terrorist activity, but the need for better security measures will always persist. Sophisticated protective devices will always invite more sophisticated threats, given the high value of security information and physical assets at military installations. The principal need is to use existing tech base work to develop Air Force application methods. The most effective physical security method, in most cases, is to deny intruders access to their targets. Fences, gates, barriers, intrusion detection systems, and guard forces all contribute to access denial. If the intruder does gain access to the target structure, it must be able to delay access or mitigate the effects of his actions. Each aspect of the overall system must be carefully designed and integrated with the other elements for best effect.

b. Subtechnology:

(1) Vehicle barriers

(2) Penetration-resistant openings

c. Any reduction in terrorist threat or the result of terrorist actions which protects life and property on military installations can yield large returns. Small increments in improved security can yield large returns in savings. Also, improved physical security will reduce operational disruption from terrorist/commando activity.

7. MOBILITY FACILITIES & EQUIPMENT:

a. The Air Force is required to execute its missions on a global scale without regard to availability of prepared airbases. Establishing an operational base in a bare base environment within 72 hours as prescribed in tactical doctrine requires expedient facilities and equipment which are compact, light, easily erected, and reliable. Most existing bare base facilities and equipment were developed over 10 years ago. New technology developments in the interim offer opportunities to substantially improve system performance and reduce transportation requirements. Since competition for transportation is always the critical element in the initial stages of contingency deployments, packing a bigger basing capability in smaller packages is an important readiness issue. Prepositioning is also an important aspect of rapid reaction capability. Longevity of components in storage and economical maintenance must also be improved. E&S personnel must erect, operate, and maintain bare base facilities and equipment. This thrust consolidates bare base development initiatives into a cohesive program which will address all aspects of this issue.

b. Subtechnology:

(1) Expedient shelters

(2) Shelter Highly Erectable Dome (SHED)

(3) Water production/purification

(4) Computerized bare base site layout

c. The Harvest Bare kits to support an F-15 wing currently weigh 1,234 tons and require approximately 60 days for complete erection. Transport of 1,234 tons requires 45 C-141B sorties. Reductions in transport requirements ease the current deficiencies in strategic airlift. Improvements in prepositioning economies directly influence force readiness and sustainability.

8. BCE PRODUCTIVITY:

a. Improved technology is a key element in industrial productivity improvement. The real property maintenance and operations budget represents a large share of the cost of running every Air Force base, and offers continuing opportunities for improvements in productivity. Even where base operating support (BOS) has been contracted, improved inspection and quality assurance techniques are needed. Other opportunities include improved heating, ventilation, and air conditioning (HVAC) controls and maintenance; dynamic equipment maintenance and inspection; and facilities evaluation/ management systems. This thrust focuses on developing better products for use in the field, and writing better specifications so that the procurement system can respond effectively.

b. Subtechnology:

(1) Construction/maintenance QA techniques

(2) NDT for facilities evaluation

(3) Improved HVAC maintainability

(4) Equipment inspection system

(5) Refrigeration

c. Improvements in BCE productivity are reflected directly in increased levels of airbase performance and reductions in O&M requirements which free more resources for operations.

C. AEROSPACE OPERATING SURFACES

1. The Pavement Research Branch (RDCP) is responsible for developing and transferring technology which will improve the way the Air Force designs, constructs, and maintains its $70 billion worth of pavements. One of our major goals is to provide the base civil engineer with an expert pavement management system sometime in the 1990's timeframe. Most of the work in the technology areas will be done in support of this goal.

2. Problems and concerns regarding airfield pavements are identified through Statement of Need (SON) process, the Engineering and Services Requirements Board (ESRB), HQ AFESC/DEMP, and field surveys. Problems identified are: limited time for airfield pavement maintenance, reliability during the design and evaluation stage, ability to meet contingency requirements, identification of data required for pavement management system, infrequent pavement evaluations, rapid runway repair, methodology for determining remaining fatigue life, and limited manpower at base level to manage pavements. These problems drive this laboratory's goal to provide the base civil engineer with an expert management system.

3. Major technologies within this branch include:

a. Pavement analysis and performance prediction,

b. Pavement design,

c. Construction, maintenance and repair, and

d. Management.

4. PAVEMENT ANALYSIS AND PERFORMANCE PREDICTION:

a. The goals of this area are to develop models to analyze pavement evaluation data and predict pavement performance as a function of aircraft loading, pavement age and environmental effects, and to develop expedient means to collect reliable pavement evaluation data with minimum pavement destruction.

b. Subtechnologies areas:

(1) Analysis and performance prediction

(2) Testing

5. PAVEMENT DESIGN:

a. The goals are to develop a universal mechanistic pavement design procedure that also incorporates reliability issues which will replace the current empirically-based design method, and the ability to design pavements able to support heavy-weight fighter aircraft that have small high-pressure tires. This design will give the pavement infrastructure the same measure of reliability as modern weapon systems.

b. Subtechnology areas:

(1) Mechanistic design

(2) High pressure tire effects

6. CONSTRUCTION, MAINTENANCE, AND REPAIR

a. Expedient construction is critical to Force Projection. The Air Force needs the capability to provide aircraft launch and recovery platforms worldwide on short notice. Current methods are too slow; labor, equipment, and material intensive; seasonally dependent; and, a logistical nightmare. Future research must focus on advanced equipment, new materials, and new construction techniques.

b. Subtechnology areas:

(1) Equipment enhancement

(2) Materials and Techniques

7. MANAGEMENT

a. The goal of this area is to develop an expert system to allow the base pavement engineer to manage the full range of pavement issues. It will allow management decisions to be made with incomplete information.

b. Subtechnology area:

(1) Expert management system

8. Aircraft pavements are an integral part of the aircraft weapons system. They must feature the same measure of reliability and survivability to maximize weapon systems effectiveness. These technologies will allow better management decisions, increase equipment life, reduce RRR construction time, substantially reduce training costs, and increase the reliability of airfield pavements.

SECTION V

ENVIRONMENTAL QUALITY TECHNOLOGY PROGRAM

A. HAZARDOUS WASTE

1. The Environmental Engineering Branch (RDVW) develops technology to allow the Air Force to comply with Federal and state environmental regulations by eliminating or reducing the generation of pollutants; developing alternative treatment technologies for industrial waste treatment and material recovery and reuse; and developing and evaluating procedures to restore contaminated land and water in support to the Defense Installation Restoration Program (IRP).

2. Major technologies within this branch include:

a. IRP technology development and field demonstrations, and

b. Waste minimization.

3. IRP TECHNOLOGY DEVELOPMENT & FIELD DEMONSTRATION

a. The Air Force has operated since the mid-1940s at locations throughout the world. While maintaining a high state of operational readiness, many fuels and chemicals were used without regard to the impact on the environment. Consequently, numerous Air Force lands and groundwater have become contaminated to the point where they are unusable. These contaminated lands and groundwater impact the ability of the Air Force to sustain operational readiness because of the necessity of using scarce operations and maintenance (O&M) resources to clean up the environment contaminated by past Air Force operations. The objective of this technology is to develop and demonstrate efficient, cost-effective procedures to restore contaminated USAF lands and groundwater to acceptable levels.

b. Technical Areas:

(1) Biodegradation

(2) Physical/chemical treatment

(3) Treatment systems

(4) Metals

(5) Subsurface fate and transport chemistry

(6) Long-term monitoring

c. The payoff to the Air Force is reduced cost to restore contaminated land and groundwater to acceptable levels. Assuming success of these programs, savings to the Air Force could be $300 million.

4. WASTE MINIMIZATION

a. The overall objective of this technology is to preclude the occurrence of land and groundwater contamination by fuels and chemicals from industrial processes currently used by the Air Force in maintaining operational readiness. Our technical approach is to develop treatment technologies and process modifications to minimize hazardous waste generated by USAF operations.

b. Industrial Operations:

(1) Depainting

(2) Electroplating

(3) Industrial cleaners and solvents

(4) Depleted uranium

(5) RRR materials

c. Development of alternative technologies for industrial waste treatment as well as material recovery and reuse will allow the Air Force to comply with environmental law and regulations in the most cost-effective manner possible.

B. AIR FORCE FUELS AND CHEMICALS

1. The Environmental Sciences Branch (RDVS) provides technology for characterizing chemical properties and environmental interactions of Air Force fuels and chemicals; develops models to assess the environmental consequences of emissions from Air Force operations; enhances instrumentation to assess the effect of fuels and chemicals on the environment; and devises pollution control technologies.

2. Major research areas within this branch include:

a. VOC and solvents,

b. Beryllium,

c. Glycidyl Azide Polymer (GAP),

d. New rocket propellants,

e. New materials,

f. New aircraft fuels,

g. Ammonium perchlorate propellants/Hydorgen chloride,

h. Hydrazine,

i. Aircraft and test cell emissions, and

j. JP-4.

Each of these research areas are further divided into four technical areas consisting of:

a. Composition. The majority of the fuel and chemicals utilized by the Air Force are purchased based on performance specifications and not on precise chemical composition. JP-4, for example, has over 250 components the concentrations of which vary not only from manufacturer to manufacturer but also vary from one manufacturer throughout the year. Determination of the chemical composition and concentration at sub part-per-million level of new and waste fuels and chemicals forms the basis for all environmental quality research.

b. Emissions. Measurement of the airborne emissions from the manufacture, storage, use, and accidental spills of fuels and chemicals provides the data necessary to assess potential environmental damages and determine compliance with environmental quality regulations.

c. Fate. Chemicals released into the environment undergo transformations which produce additional, potentially harmful substances. These chemicals may partition between the air, soil, and water. Understanding these transformations and determining the ultimate fate of the chemicals in the environment are necessary to predict the environmental degradation. This area also includes hazard response modeling to provide on-scene commanders with predictions of the extent of toxic effects resulting from accidental releases of fuels and chemicals.

d. Treatment & disposal. Information from the other three areas is utilized to develop effective technologies and procedures to prevent, minimize, and control the release of hazardous substances to the environment.

3. This technology develops, tests, and evaluates pollution control procedures allowing the Air Force to conduct peacetime missions without delay from environmental litigation, and to expediently deploy and operate weapon systems without environmental degradation.

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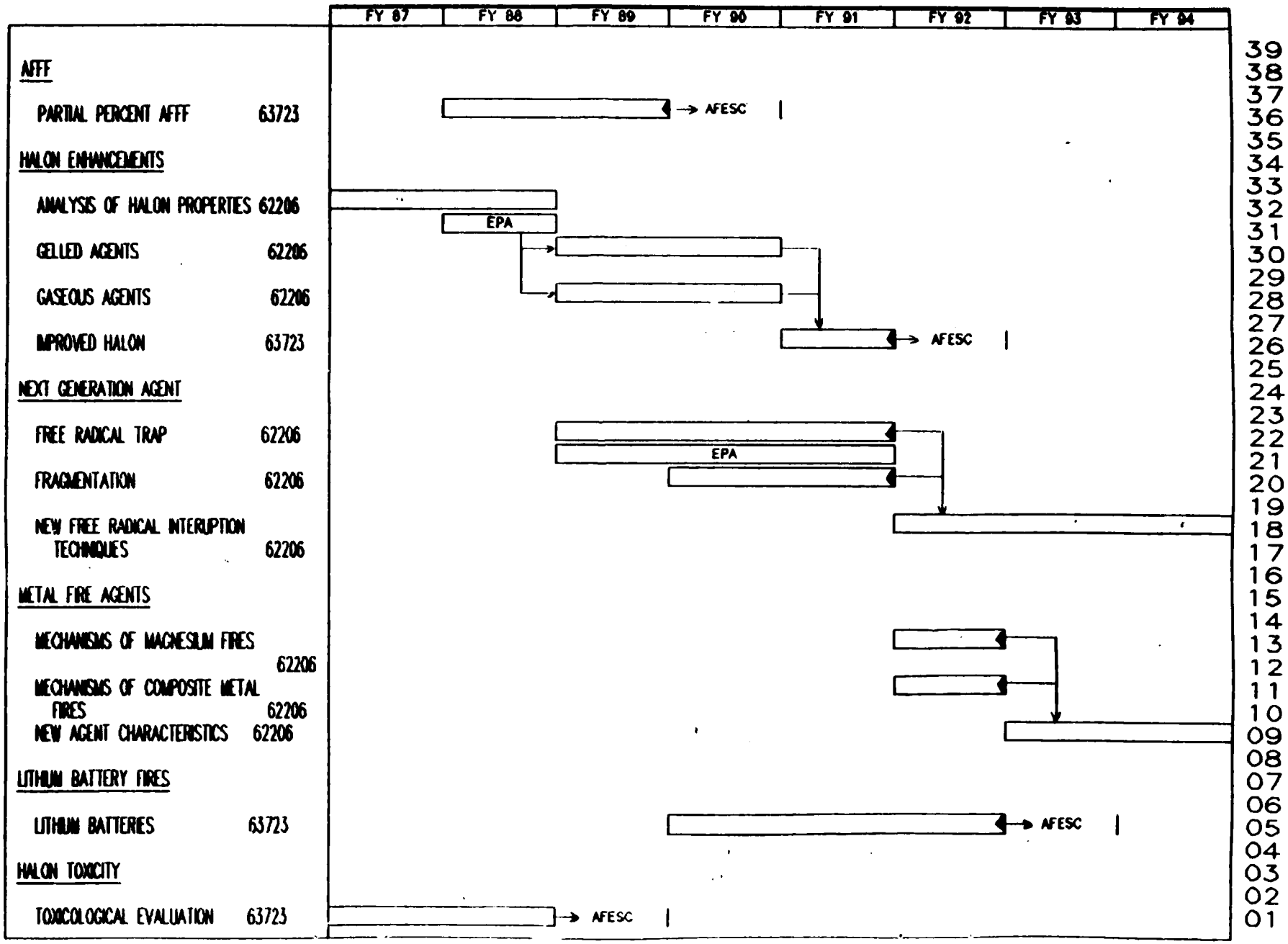
FIRE

PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FIRE
TECH: ENHANCED AGENTS

GOAL: DEVELOP CLEAN, NONTOXIC, ENVIRONMENTALLY BENIGN AGENTS EFFECTIVE AGAINST 3-DIMENSIONAL FIRES.

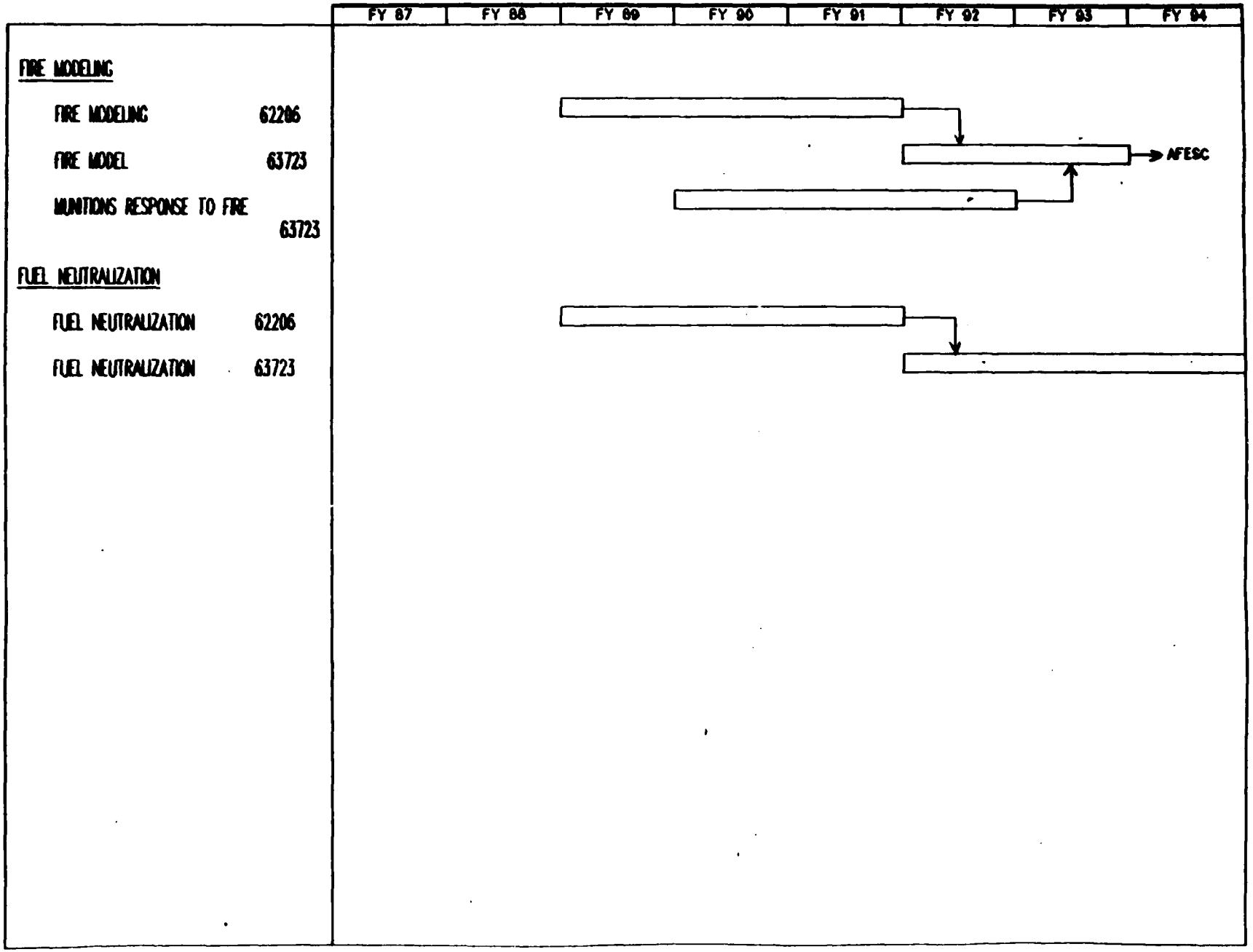
DATE: 24 JULY 1987
ROADMAP: AAENH-0795q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FIRE
TECH: PHYSICS OF FIRE

GOAL: DEVELOP THE TECHNOLOGY FOR UNDERSTANDING THE MECHANISMS OF COMBUSTION PHYSICS.

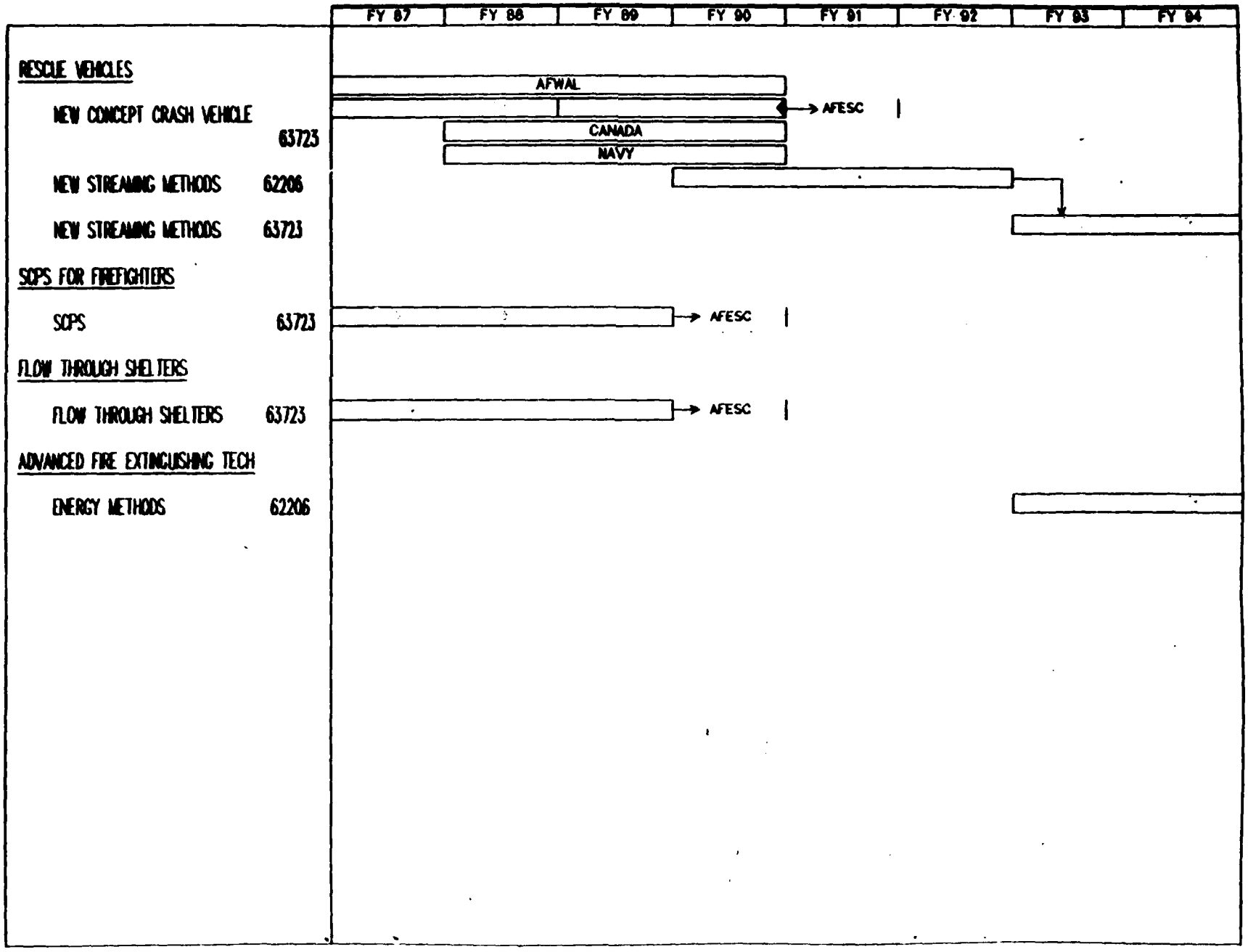
DATE: 24 JULY 1987
ROADMAP: ADPHY-0800q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FIRE
TECH: ADVANCED EQUIPMENT AND VEHICLES

GOAL: DEVELOP FIREFIGHTING SYSTEMS WHICH WILL ENHANCE AIR FORCE ABILITY TO SURVIVE AND FUNCTION IN A WARTIME ENVIRONMENT.

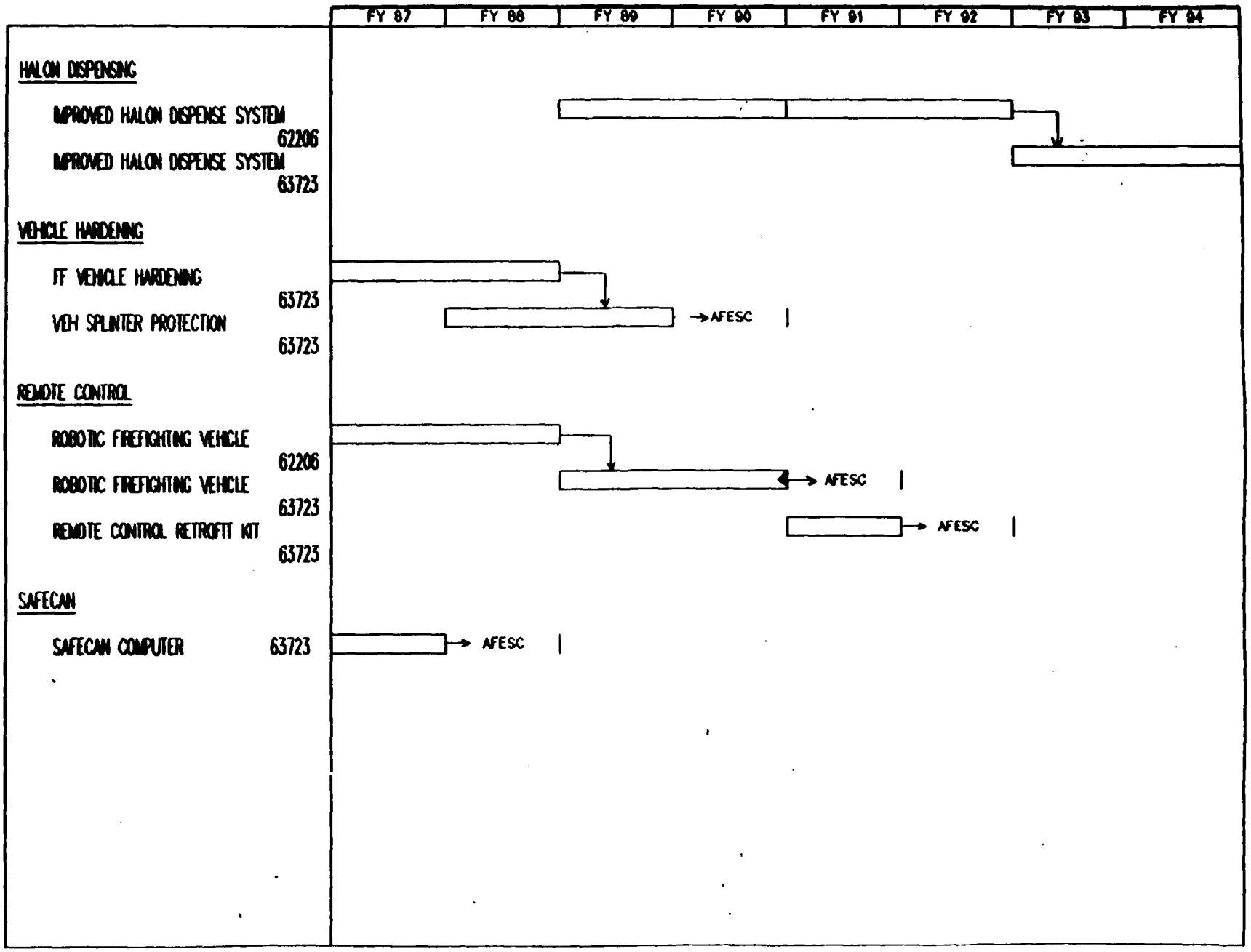
DATE: 24 JULY 1987
ROADMAP: ABADV-0796q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FIRE
TECH: ADVANCED EQUIPMENT & VEHICLES (CONT)

GOAL: DEVELOP FIREFIGHTING SYSTEMS WHICH WILL ENHANCE AIR FORCE ABILITY TO SURVIVE AND FUNCTION IN A WARTIME ENVIRONMENT.

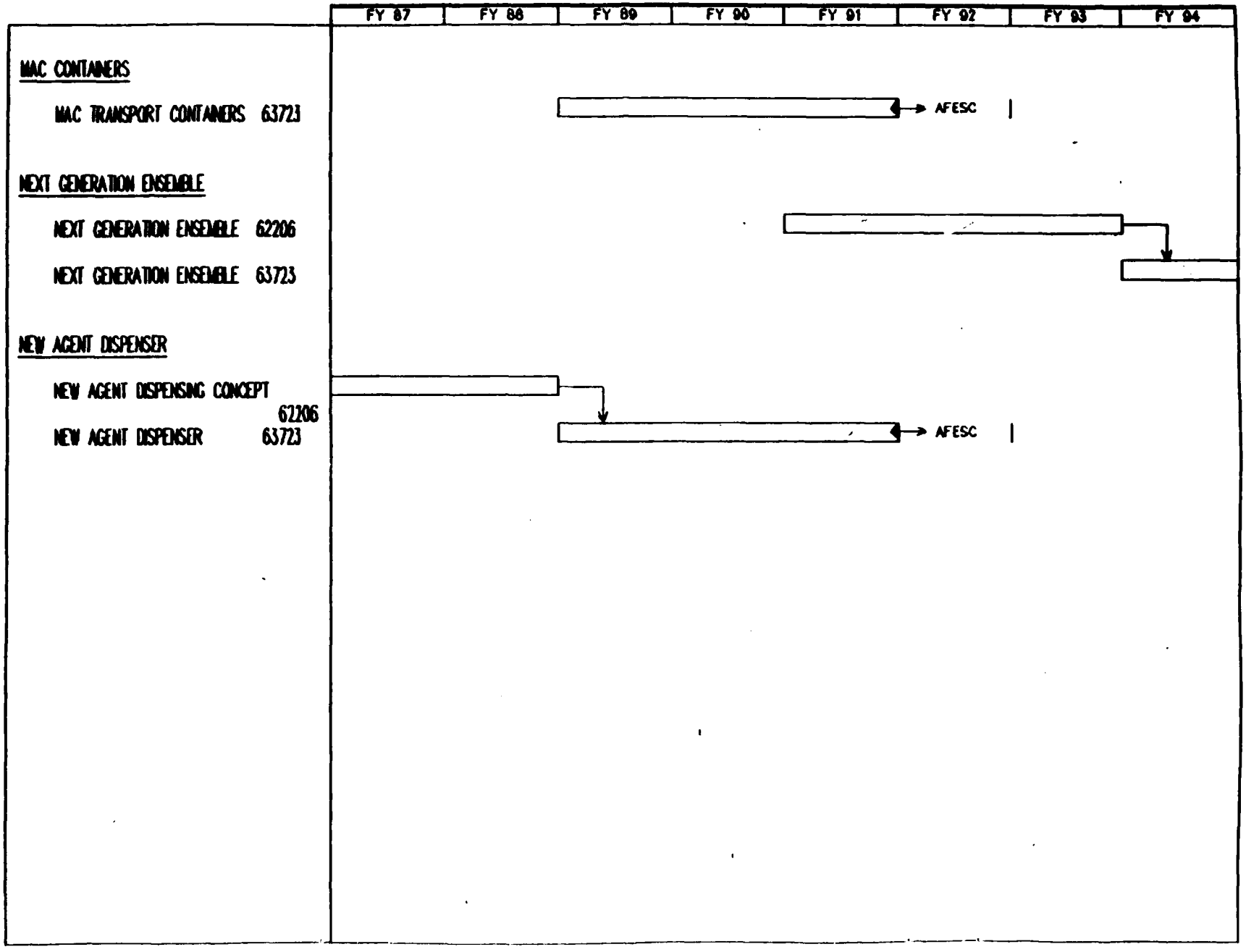
DATE: 24 JULY 1987
ROADMAP: ABAD1-0797q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FIRE
TECH: ADVANCED EQUIPMENT & VEHICLES (CONT)

GOAL: DEVELOP FIREFIGHTING SYSTEMS WHICH WILL ENHANCE AIR FORCE ABILITY TO SURVIVE AND FUNCTION IN A WARTIME ENVIRONMENT.

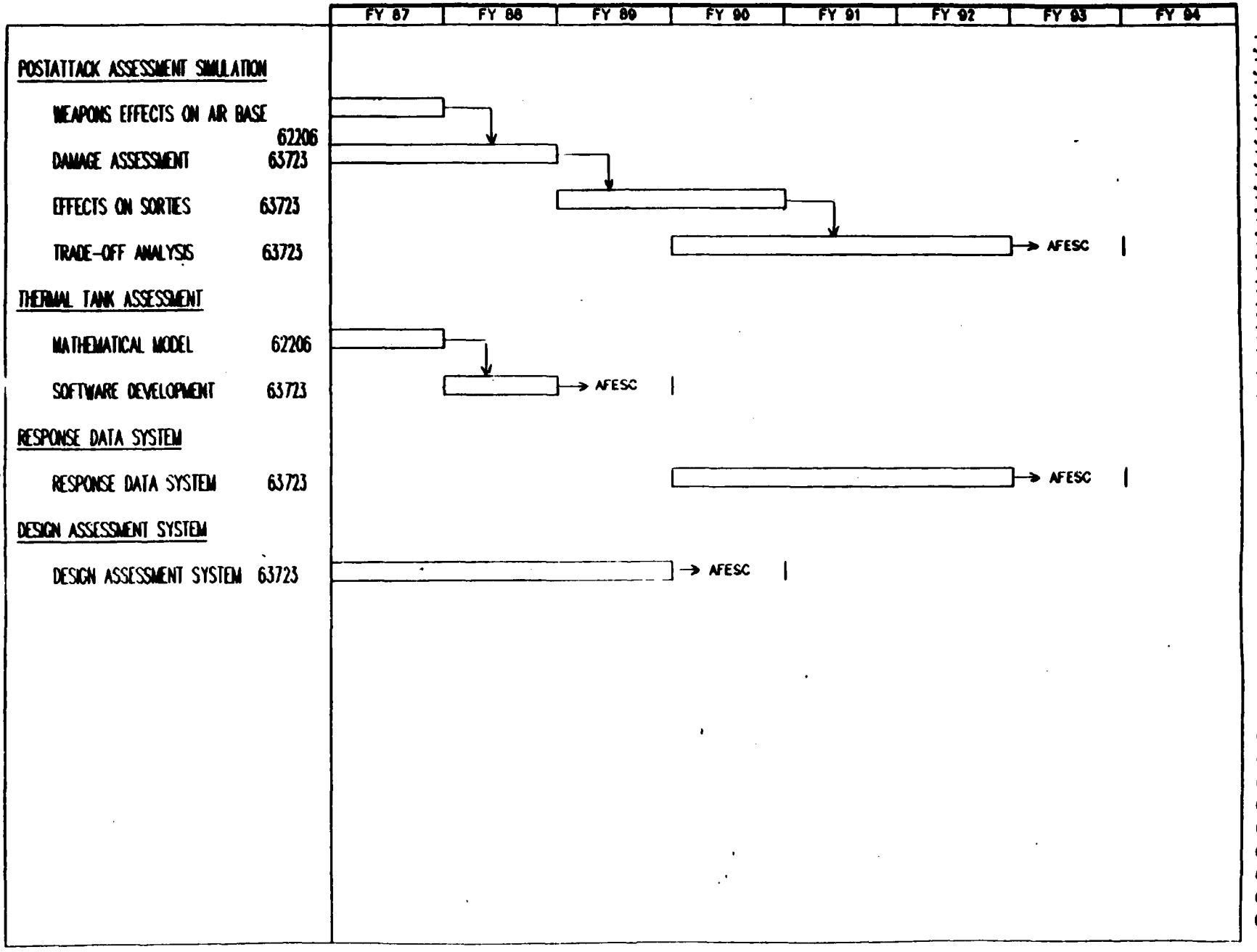
DATE: 24 JULY 1987
ROADMAP: ABAD2-0798q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FIRE
TECH: FIRE ASSESSMENT

GOAL: DEVELOP THE TECHNOLOGY FOR ASSESSING OPTIMUM FIRE PREVENTION/PROTECTION OF AN AIR BASE DURING WARTIME AND PEACETIME.

DATE: 24 JULY 1987
ROADMAP: AEFIR-0801q
OPR: AFESC/RD



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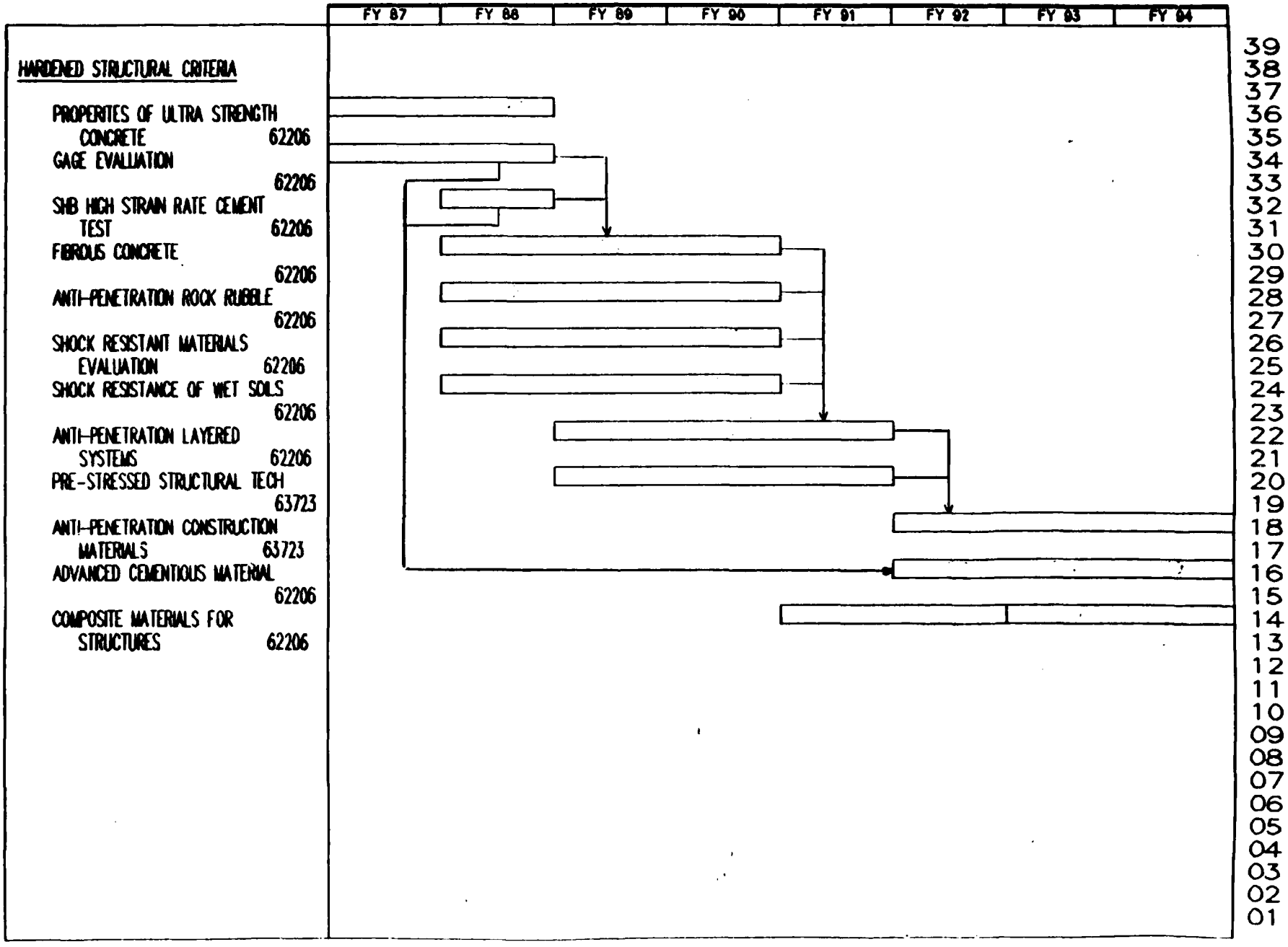
FACILITY SYSTEMS AND ANALYSIS

PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: SURVIVABLE STRUCTURES

GOAL: PROVIDE THE TECHNOLOGIES FOR MORE ECONOMICAL HARDENING METHODS OF CRITICAL AIR FORCE FACILITIES.

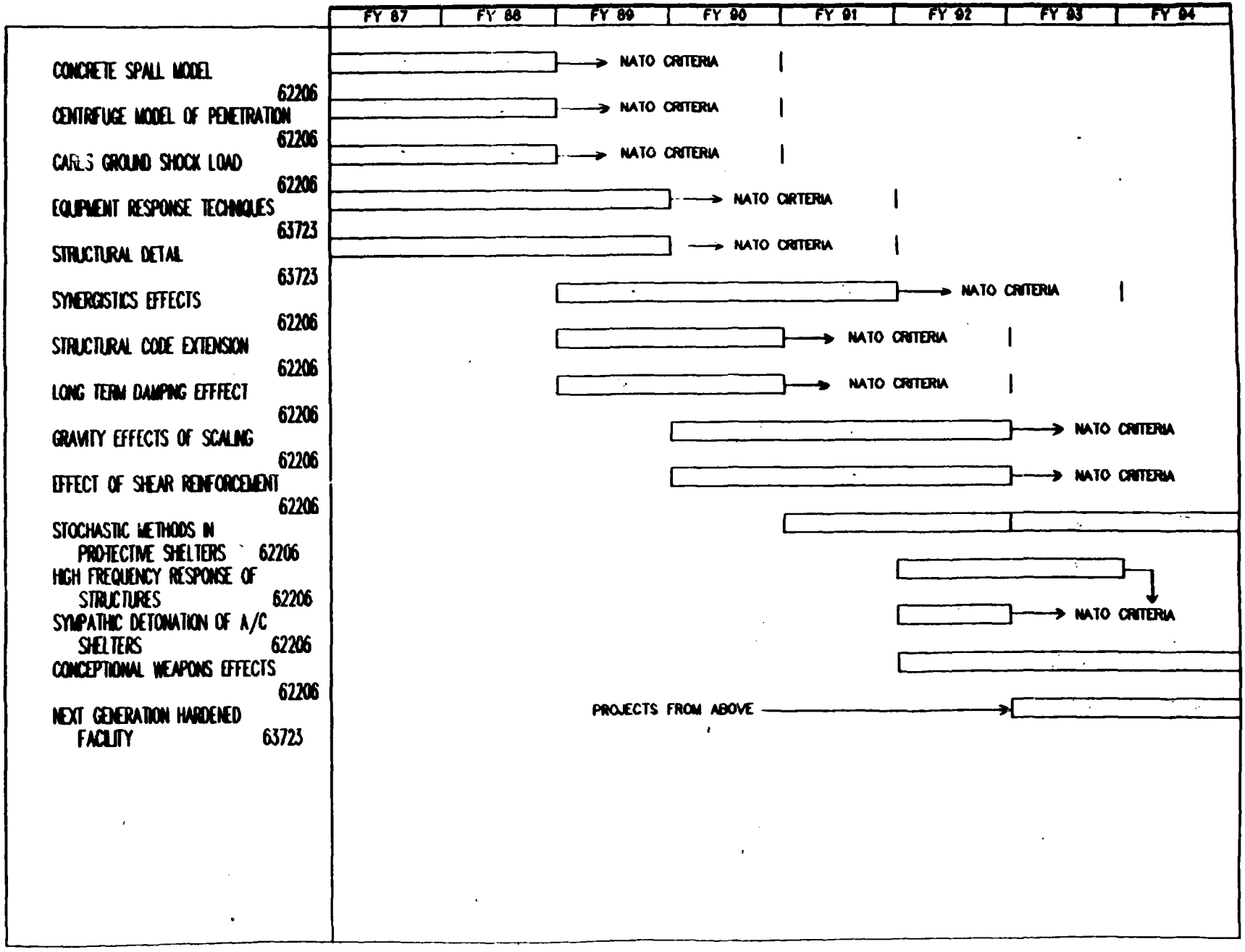
DATE: 24 JULY 1987
ROADMAP: CASUR-0787q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: SURVIVABLE STRUCTURES
CONT.

GOAL: PROVIDE THE TECHNOLOGIES FOR MORE ECONOMICAL HARDENING METHODS OF CRITICAL AIR FORCE FACILITIES.

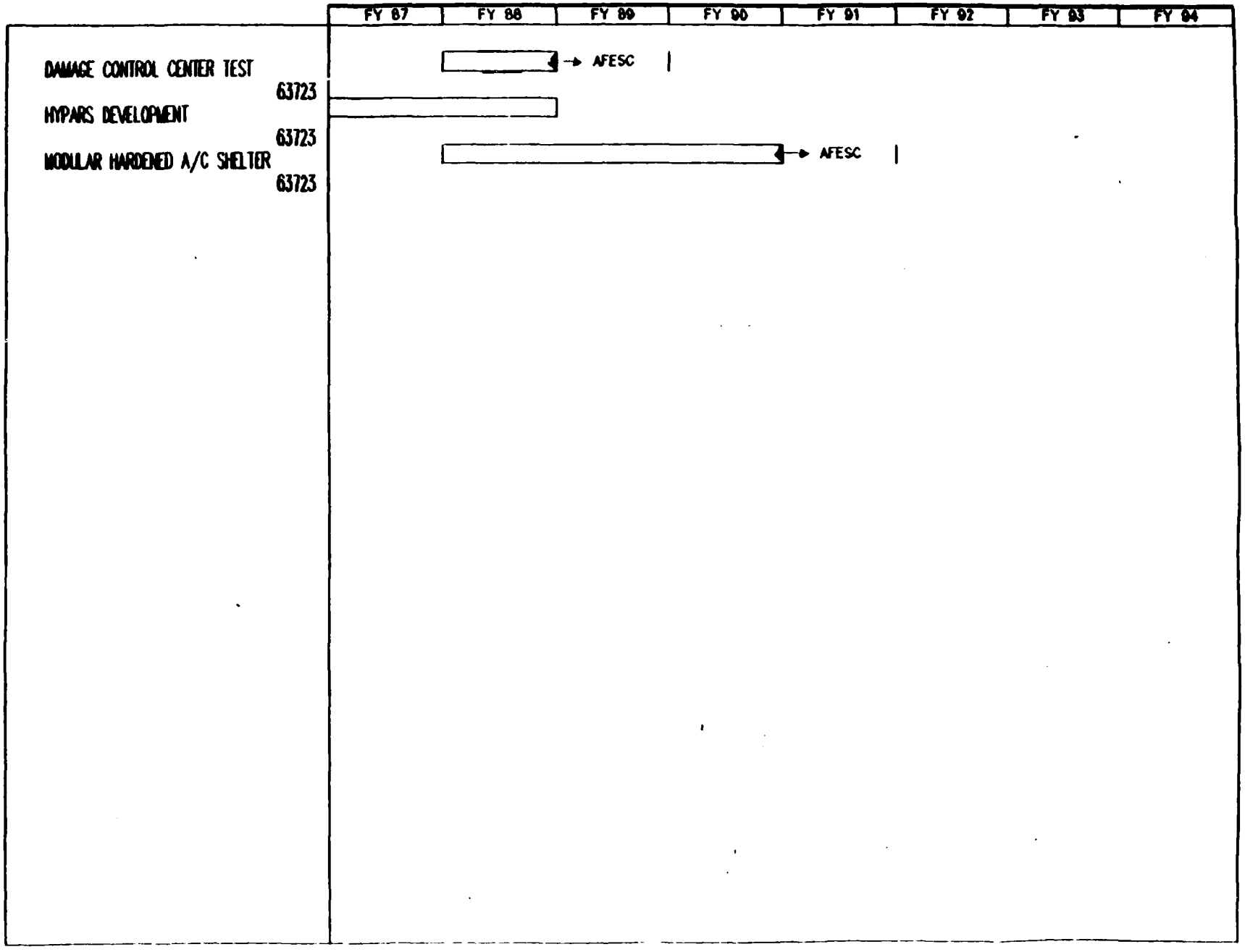
DATE: 24 JULY 1987
ROADMAP: CJTE2-0794q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: SURVIVABLE STRUCTURES
(CONT)

GOAL: PROVIDE THE TECHNOLOGIES FOR MORE ECONOMICAL HARDENING METHODS OF CRITICAL AIR FORCE FACILITIES.

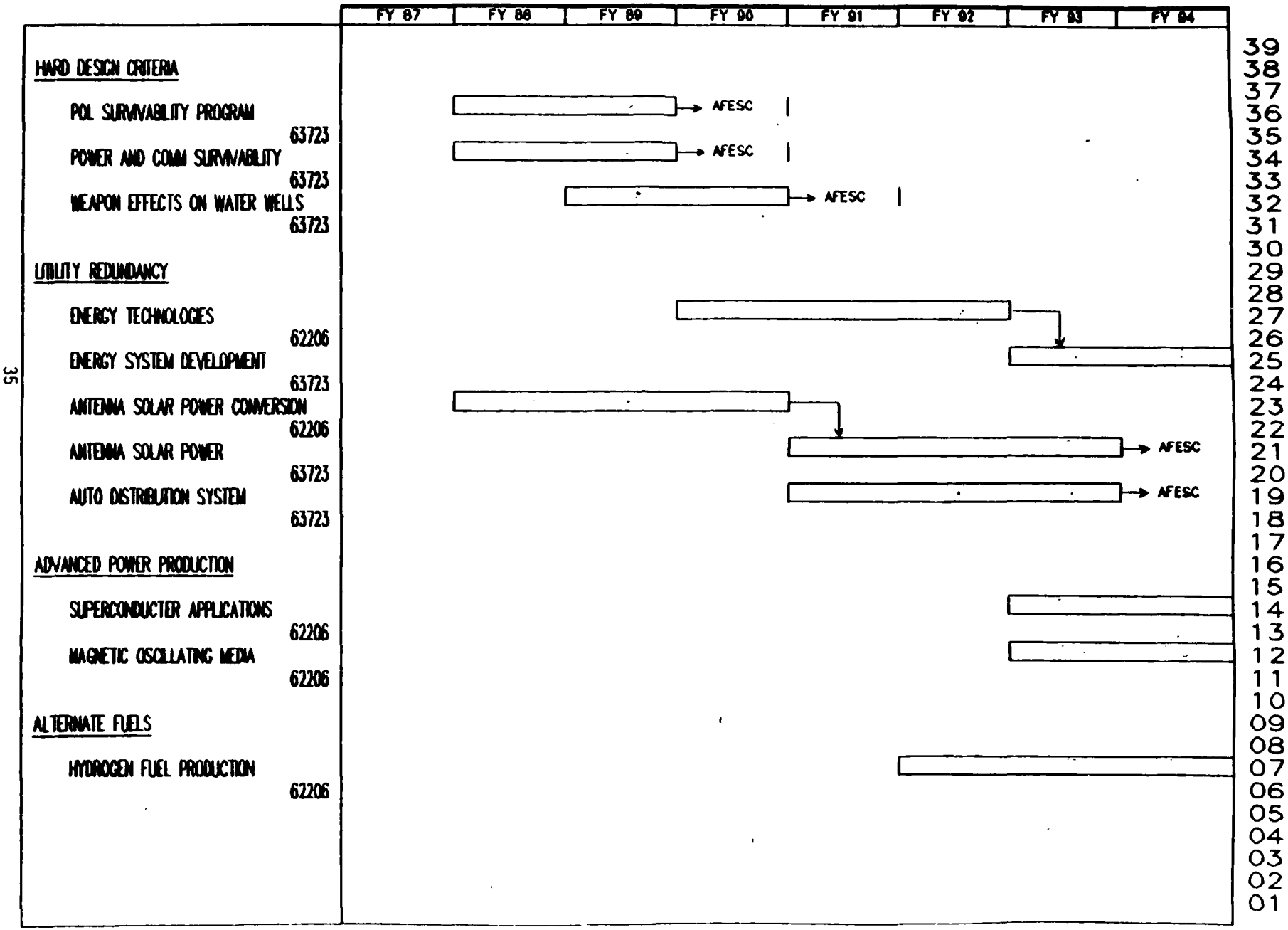
DATE: 24 JULY 1987
ROADMAP: CJTE1-0875q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: UTILITIES
TECH: SURVIVABLE UTILITIES

GOAL: PROVIDE THE TECHNOLOGY FOR IMPROVED SURVIVABLE AND RELIABLE UTILITY SYSTEMS.

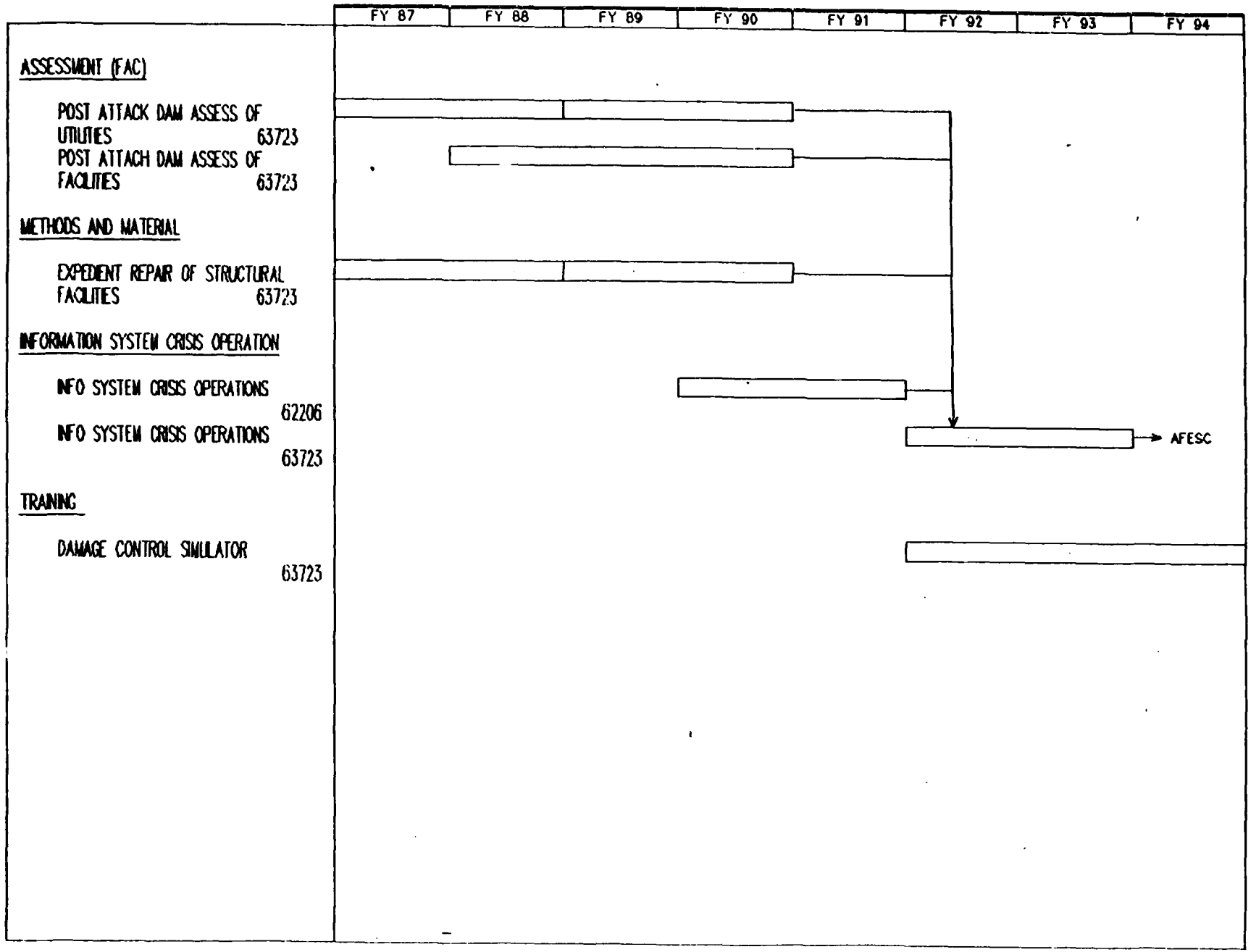
DATE: 24 JULY 1987
ROADMAP: CBSUR-0826q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: FACILITY RECOVERY

GOAL: PROVIDE NEW TECHNOLOGY FOR ASSESSING AND REPAIRING CRITICAL AIR BASE FUNCTIONS IN A POSTATTACK ENVIRONMENT.

DATE: 24 JULY 1987
ROADMAP: CCDAM-0802q
OPR: AFESC/RD

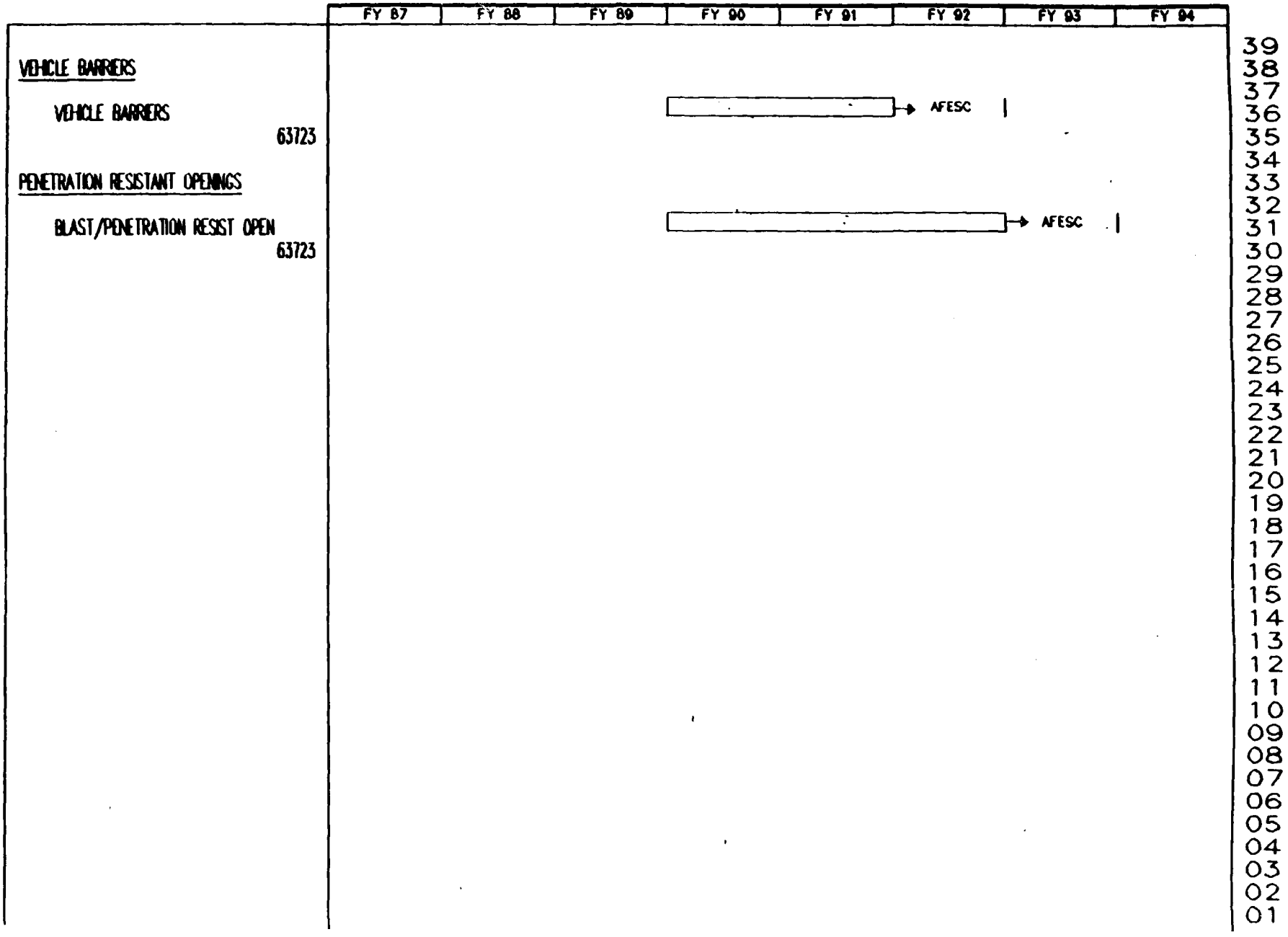


88-008

PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: PHYSICAL SECURITY

GOAL: DEVELOP THE TECHNOLOGY TO IMPROVE PHYSICAL PROTECTION OF AIR BASE FACILITIES AGAINST TERRORISM AND SABOTAGE.

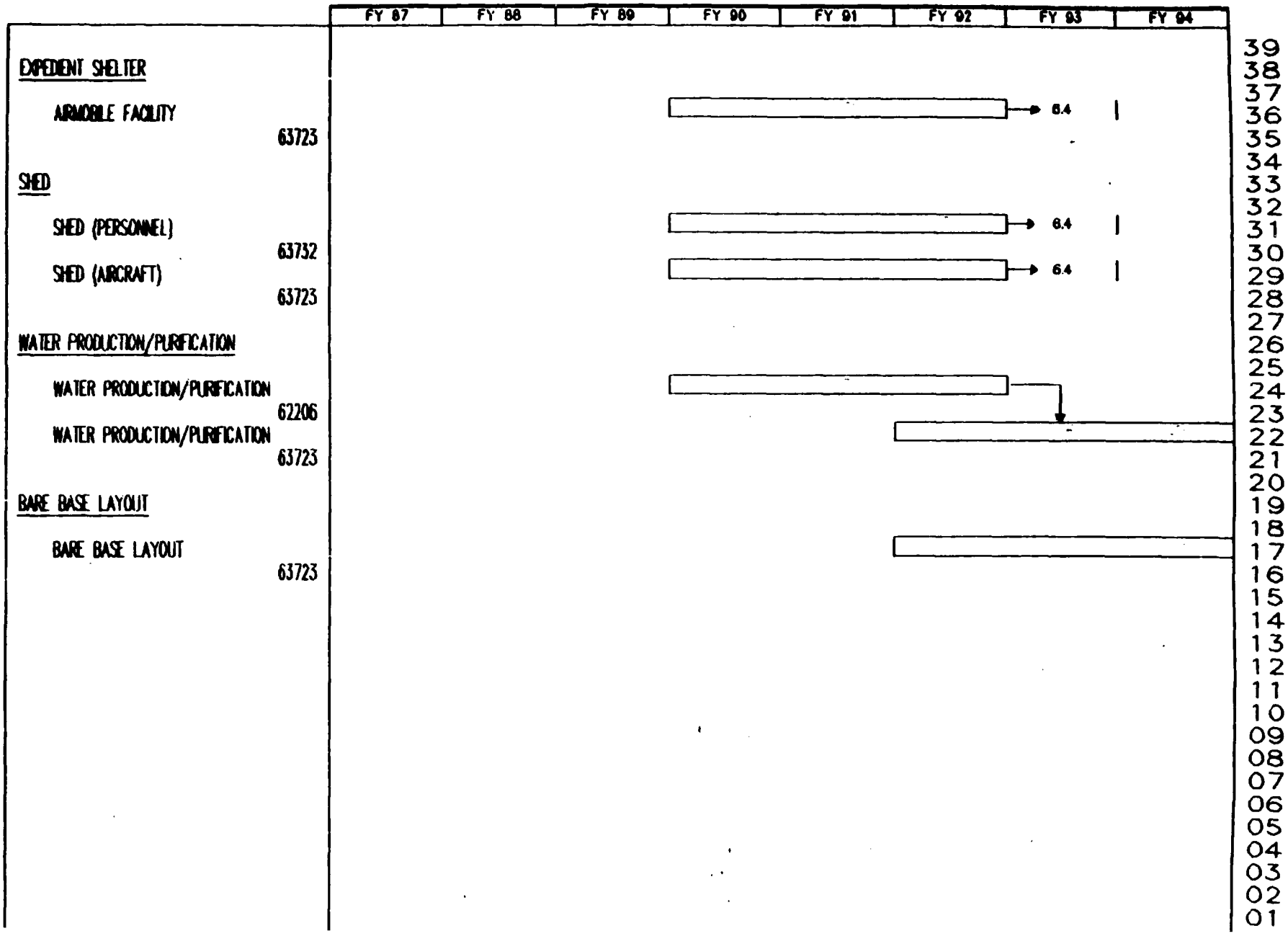
DATE: 24 JULY 1987
ROADMAP: CEPHY-0790q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: MOBILITY FACILITIES & EQUIPMENT

GOAL: PROVIDE THE TECHOLOGY TO IMPROVE TACTICAL MOBILITY SHELTERS AND ASSOCIATED SYSTEMS.

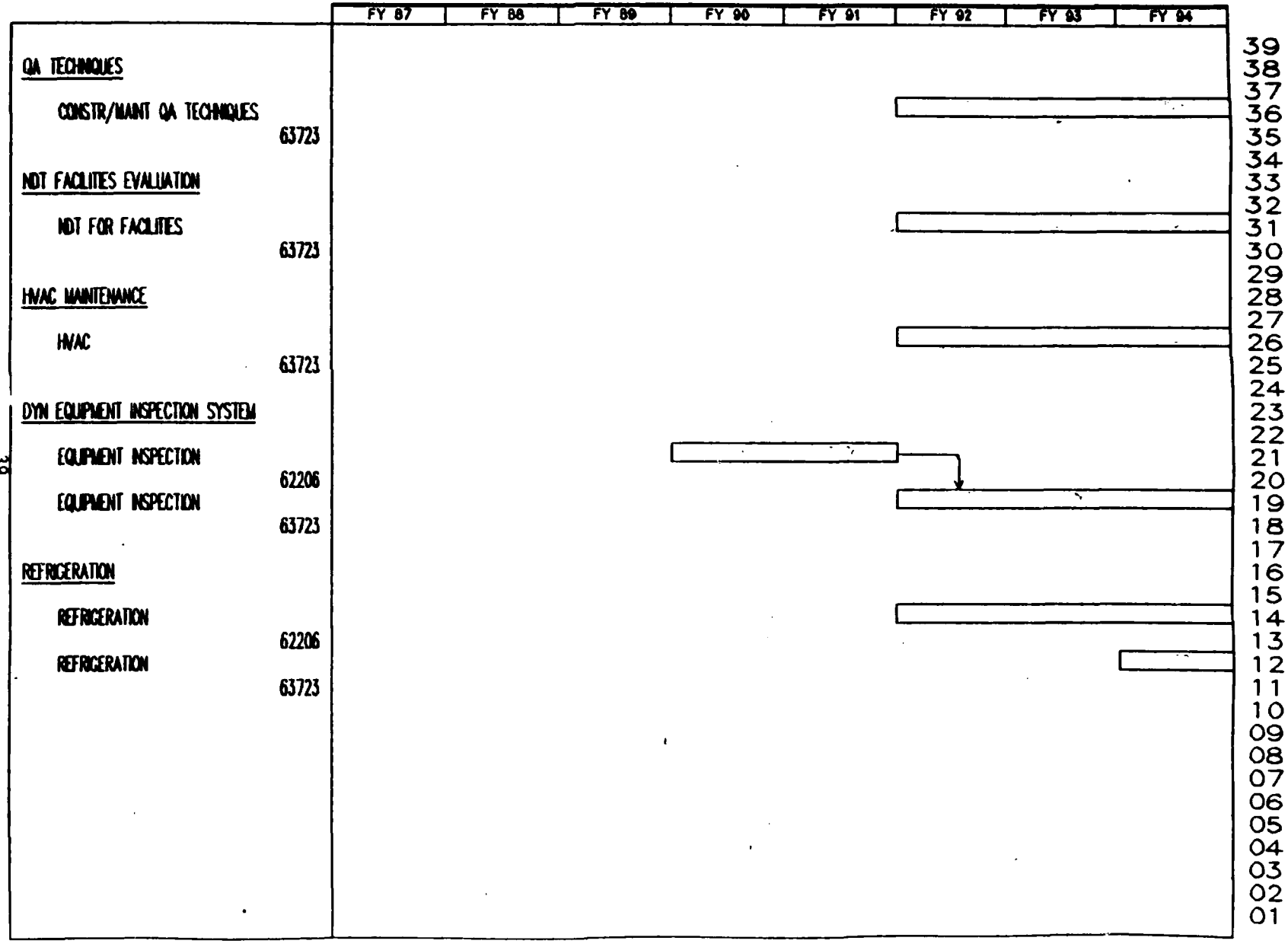
DATE: 24 JULY 1987
ROADMAP: CFMOB-07/91
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FACILITIES
TECH: BCE PRODUCTIVITY

GOAL: DEVELOP TECHNOLOGIES TO INCREASE AIR BASE PERFORMANCE AND REDUCE O&M COSTS.

DATE: 24 JULY 1987
ROADMAP: CHBCE-0792q
OPR: AFESC/RD



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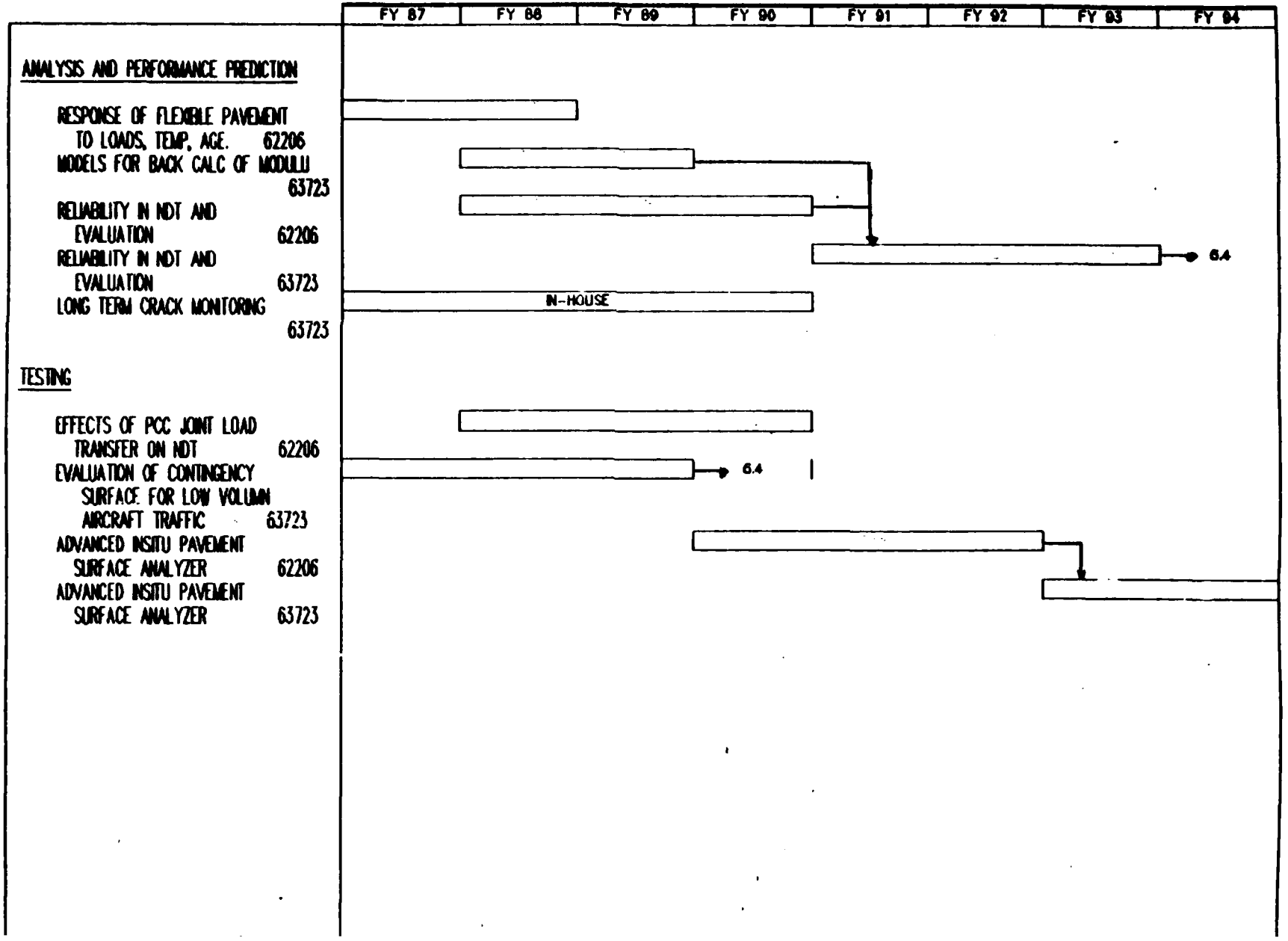
AEROSPACE OPERATING
SURFACES

PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: AEROSPACE OPS SURFACES
TECH: PAVEMENT EVALUATION AND PERFORMANCE PREDICTION

GOAL: DEVELOP METHODS TO RAPIDLY DETERMINE AND PREDICT PAVEMENT CONDITION AND CAPACITY INCORPORATING LOAD, AGE, AND NEW EFFECTS.

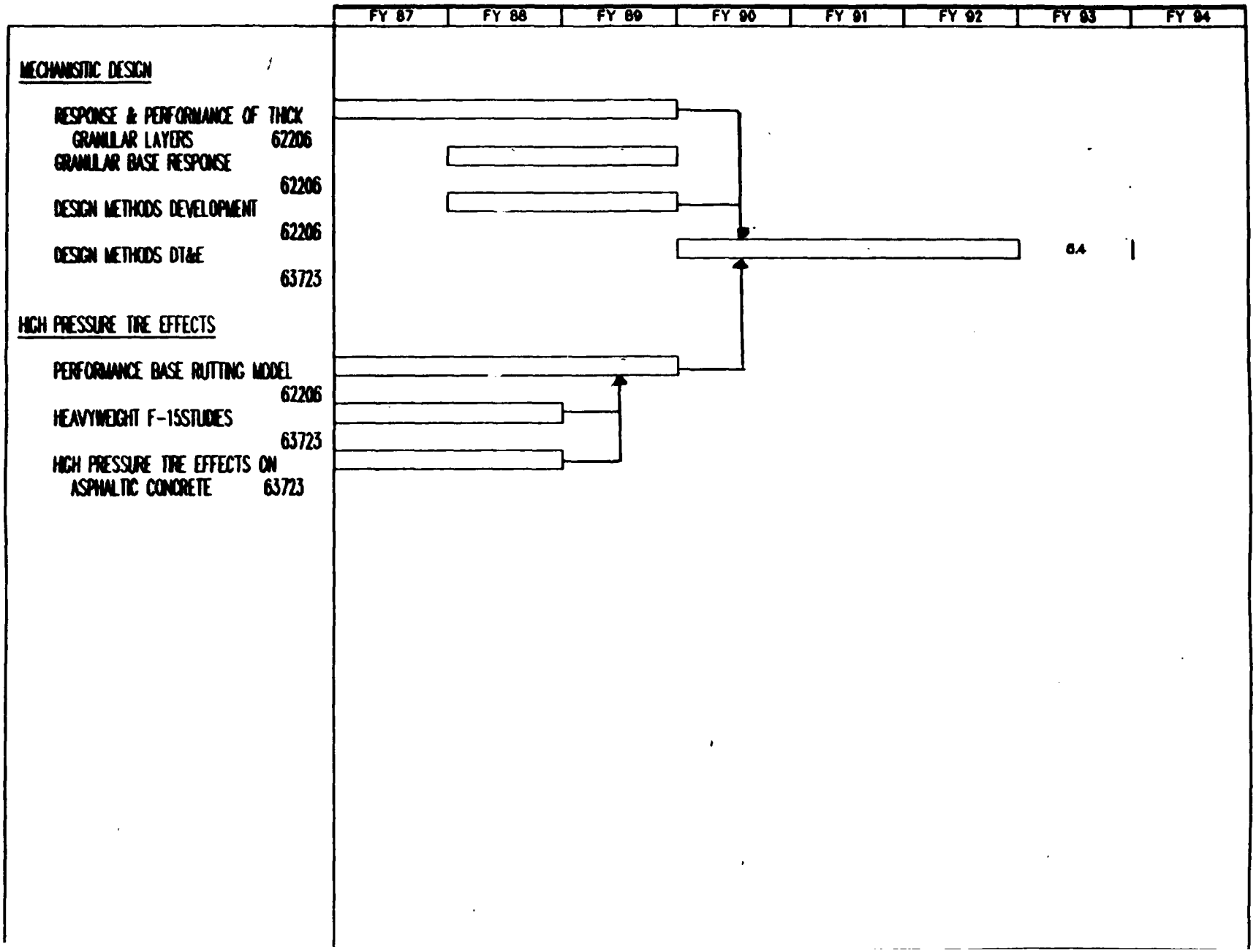
DATE: 24 JULY 1987
ROADMAP: BAL01-0858q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: AEROSPACE OPS SURFACES
TECH: PAVEMENT DESIGN

GOAL: DEVELOP A UNIVERSAL MECHANISTIC PAVEMENT DESIGN PROCEDURE INCORPORATING RELIABILITY ISSUES.

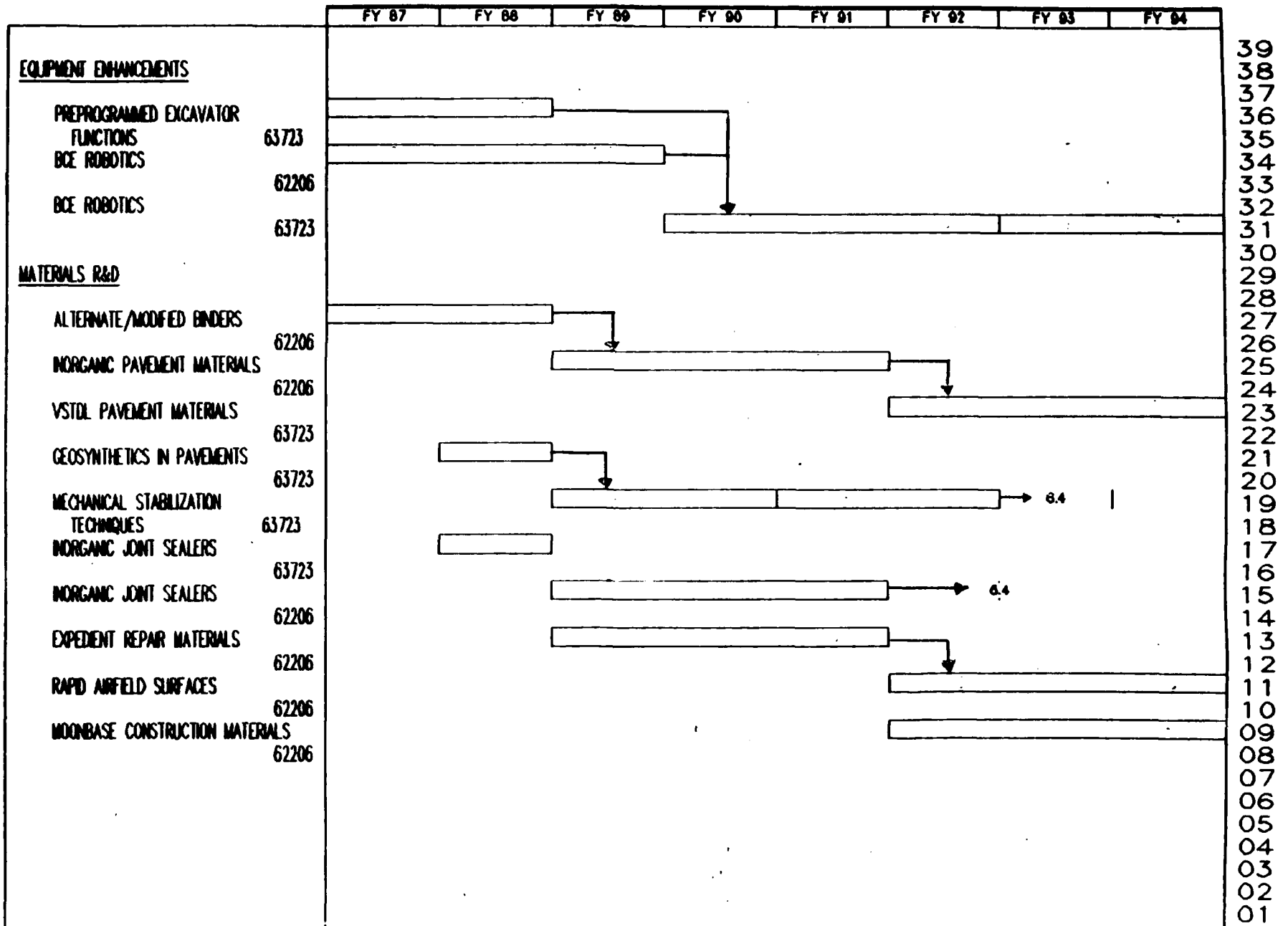
DATE: 24 JULY 1987
ROADMAP: BAL02-0860q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: AEROSPACE OPS SURFACES
TECH: CONSTRUCTION, MAINTENANCE, AND REPAIR

GOAL: DEVELOP METHODS, MATERIALS, AND EQUIPMENT TO CONSTRUCT, MAINTAIN AND REPAIR AEROSPACE OPERATING SURFACES.

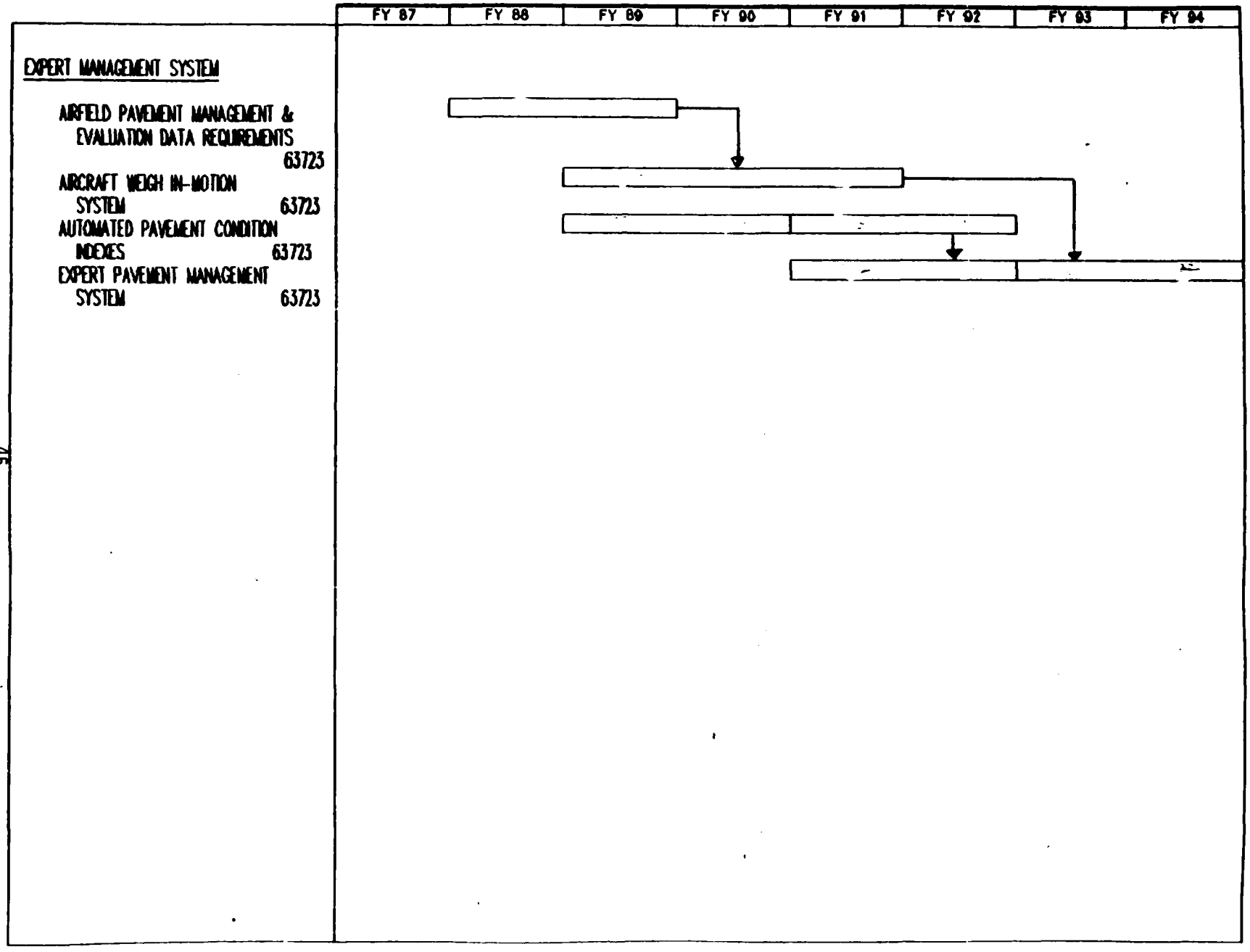
DATE: 24 JULY 1987
ROADMAP: BAL03-0864q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: AEROSPACE OPS SURFACES
TECH: MANAGEMENT

GOAL: DEVELOP AN EXPERT SYSTEM TO MANAGE AEROSPACE OPERATING SURFACES.

DATE: 24 JULY 1987
ROADMAP: BBBAR-0b61q
OPR: AFESC/RD



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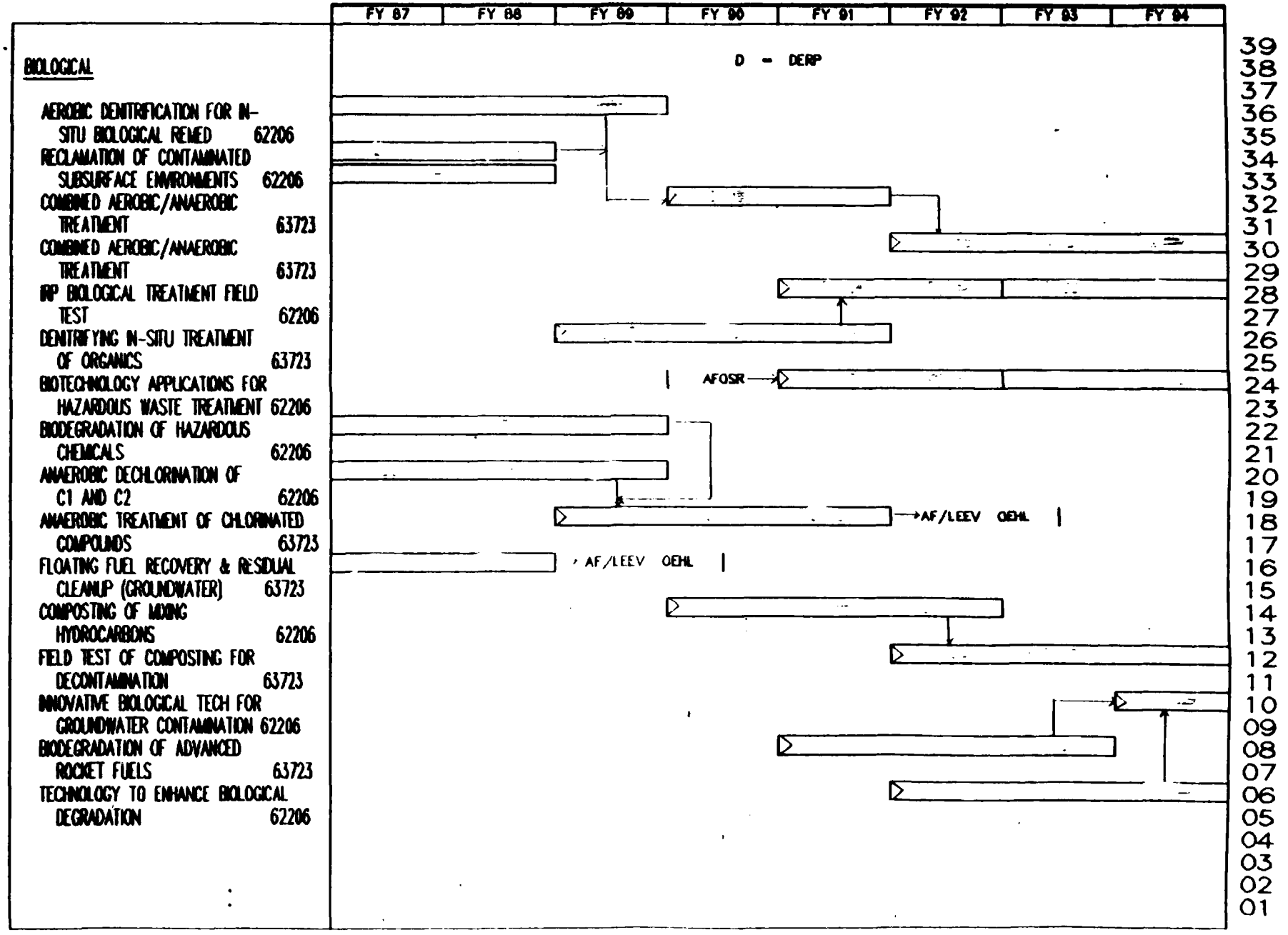
HAZARDOUS WASTE

PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: IRP TECHNOLOGY DEVELOPMENT & FIELD DEMONSTRATIONS

GOAL: TO DEVELOP AND DEMO EFFICIENT, COST-EFFECTIVE TECHNOLOGIES TO RESTORE CONTAMINATED USAF LAND AND GROUNDWATER TO ACCEPTABLE LEVELS.

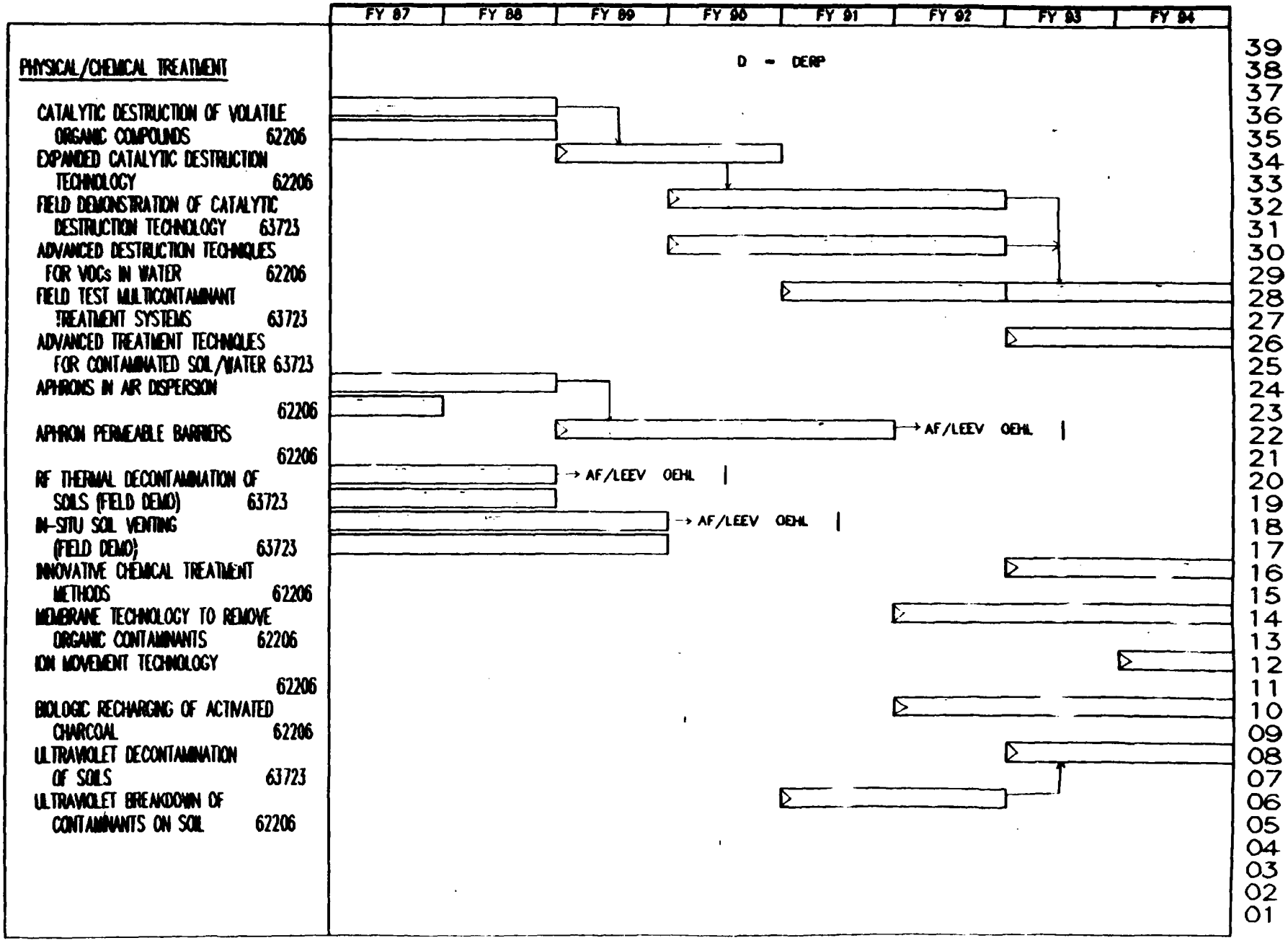
DATE: 24 JULY 1987
ROADMAP: EBIR1-0819q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: IRP TECHNOLOGY DEVELOPMENT & FIELD DEMONSTRATIONS (CONT)

GOAL: TO DEVELOP AND DEMO EFFICIENT, COST-EFFECTIVE TECHNOLOGIES TO RESTORE CONTAMINATED USAF LAND AND GROUNDWATER TO ACCEPTABLE LEVELS.

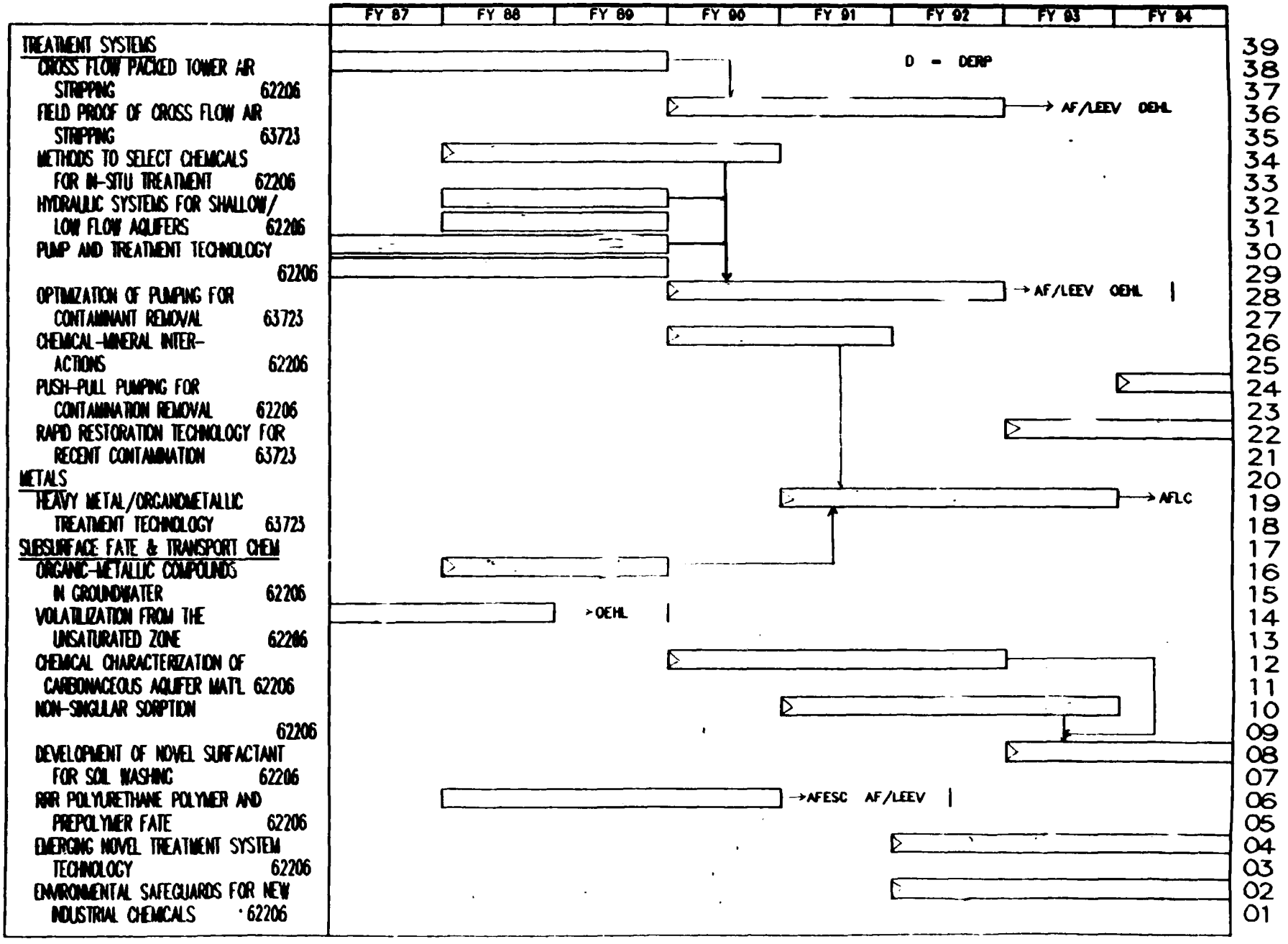
DATE: 24 JULY 1987
ROADMAP: EBIR4-0878q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: IRP TECHNOLOGY DEVELOPMENT & FIELD DEMONSTRATIONS (CONT)

GOAL: TO DEVELOP AND DEMO EFFICIENT, COST-EFFECTIVE TECHNOLOGIES TO RESTORE CONTAMINATED USAF LAND/GROUNDWATER TO ACCEPTABLE LEVELS.

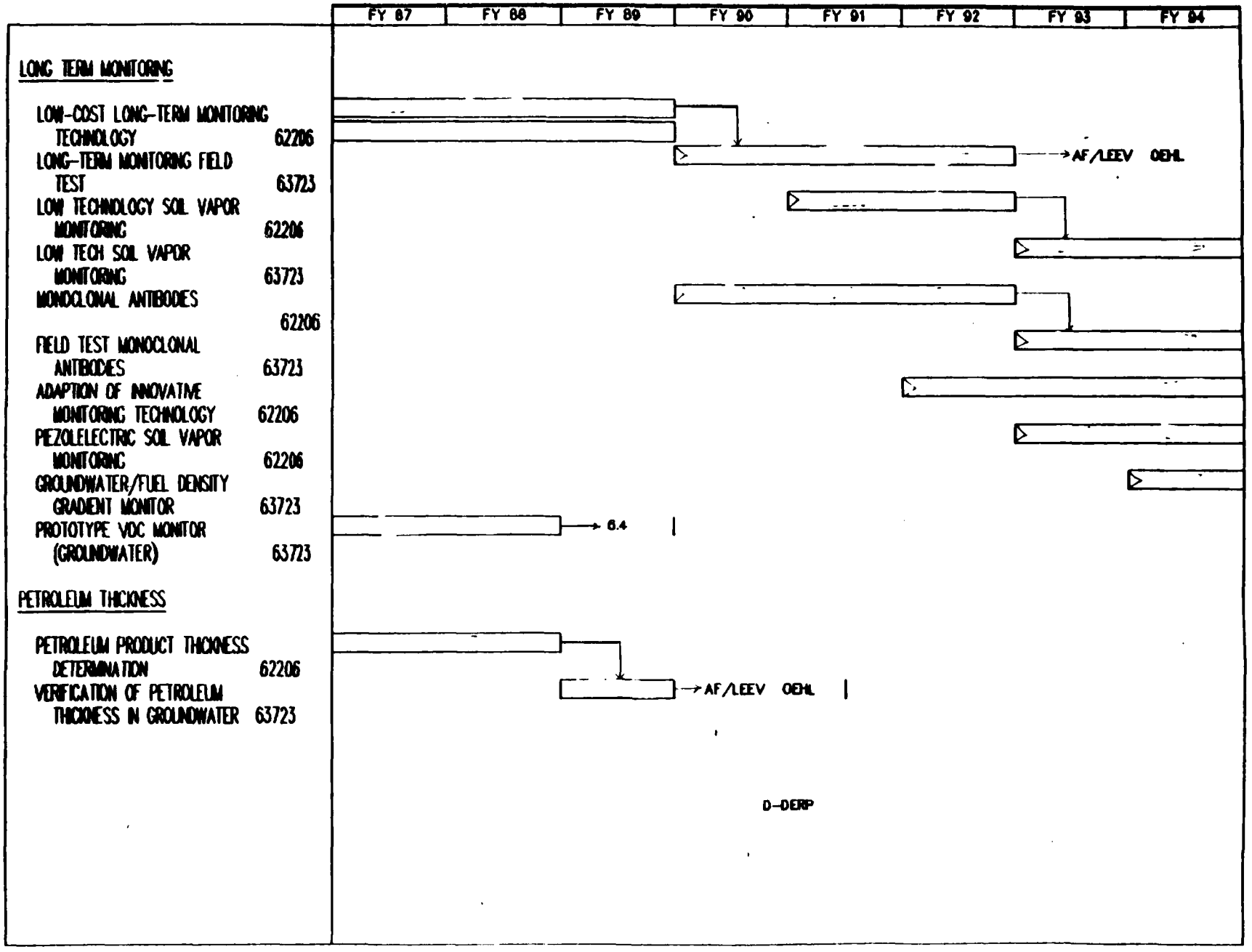
DATE: 24 JULY 1987
ROADMAP: EBIR2-0820q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: IRP TECHNOLOGY DEVELOPMENT & FIELD DEMONSTRATIONS (CONT)

GOAL: TO DEVELOP AND DEMO EFFICIENT, COST-EFFECTIVE TECHNOLOGIES TO RESTORE CONTAMINATED USAF LAND AND GROUNDWATER TO ACCEPTABLE LEVELS.

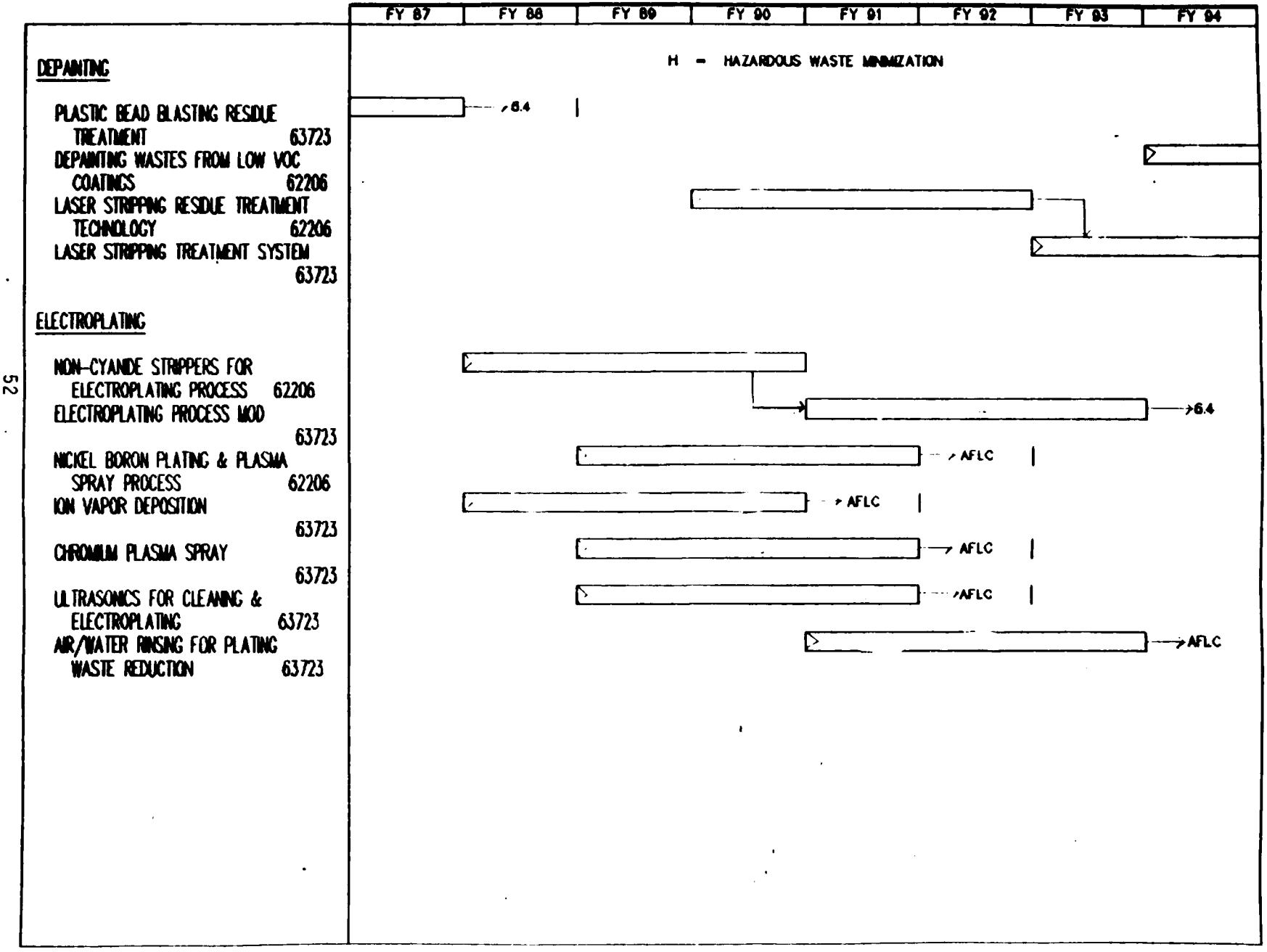
DATE: 24 JULY 1987
ROADMAP: EBIR3-0821q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: WASTE MINIMIZATION

GOAL: TO DEVELOP TREATMENT TECHNOLOGIES AND PROCESS MODIFICATIONS TO MINIMIZE HAZARDOUS WASTES GENERATED BY USAF OPERATIONS.

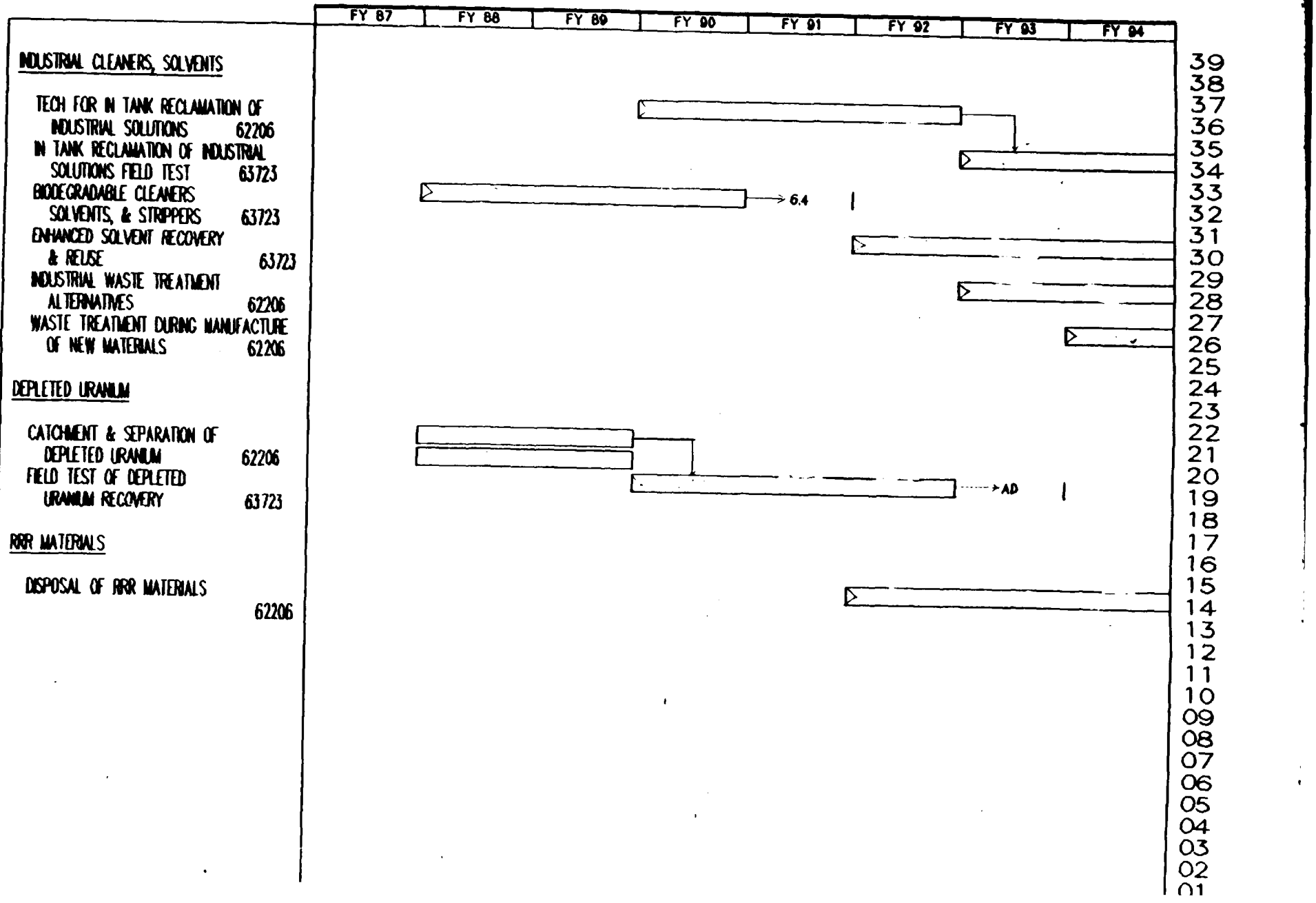
DATE: 24 JULY 1987
ROADMAP: EBWA1-0817q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: WASTE MINIMIZATION
(CONT)

GOAL: TO DEVELOP TREATMENT TECHNOLOGIES AND PROCESS MODIFICATIONS TO MINIMIZE HAZARDOUS WASTES GENERATED BY USAF OPERATIONS.

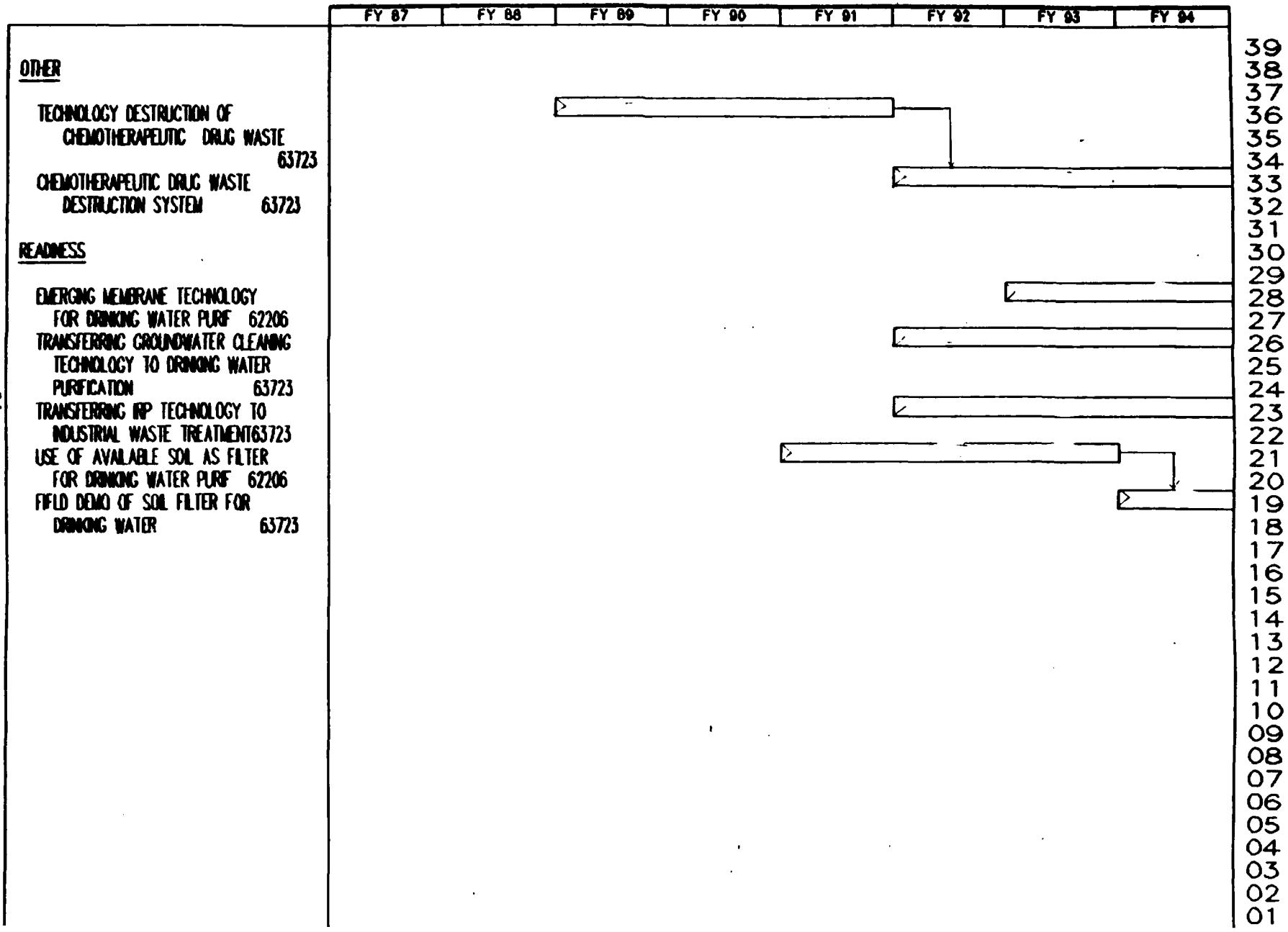
DATE: 24 JULY 1987
ROADMAP: EBWA3-0908q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: HAZARDOUS WASTE
TECH: WASTE MINIMIZATION (CONT)

GOAL: TO DEVELOP TREATMENT TECHNOLOGIES AND PROCESS MODIFICATIONS TO MINIMIZE HAZARDOUS WASTES GENERATED BY USAF OPERATIONS.

DATE: 24 JULY 1987
ROADMAP: EBWA2-0818q
OPR: AFESC/RD

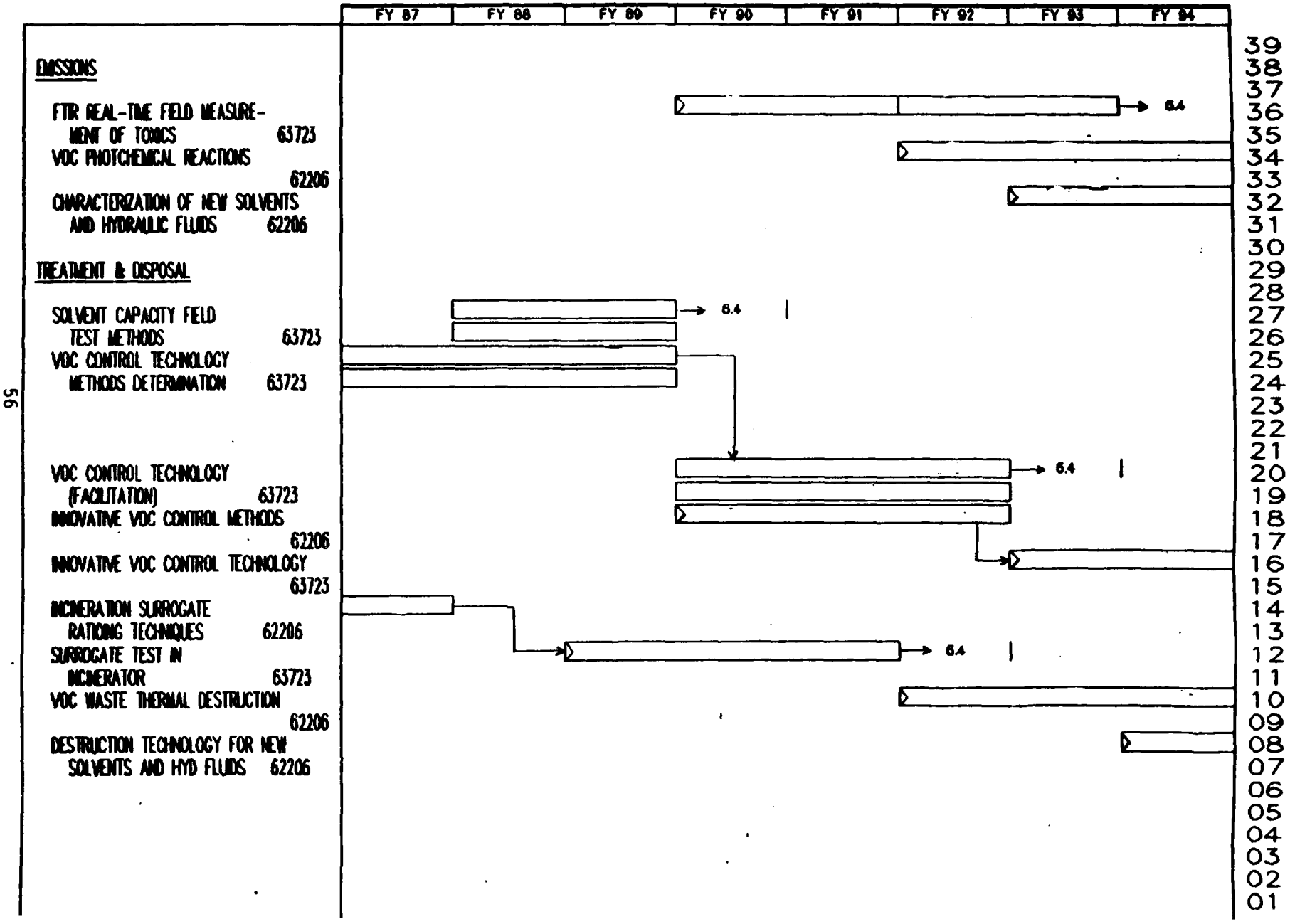


FUELS AND CHEMICALS

PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: VOC & SOLVENTS

GOAL: TO DEVELOP TECHNOLOGIES TO MEASURE THE MAGNITUDE OF THE ENVIRONMENTAL IMPACT OF VOCs FROM USAF OPERATIONS AND TO MINIMIZE THIS IMPACT.

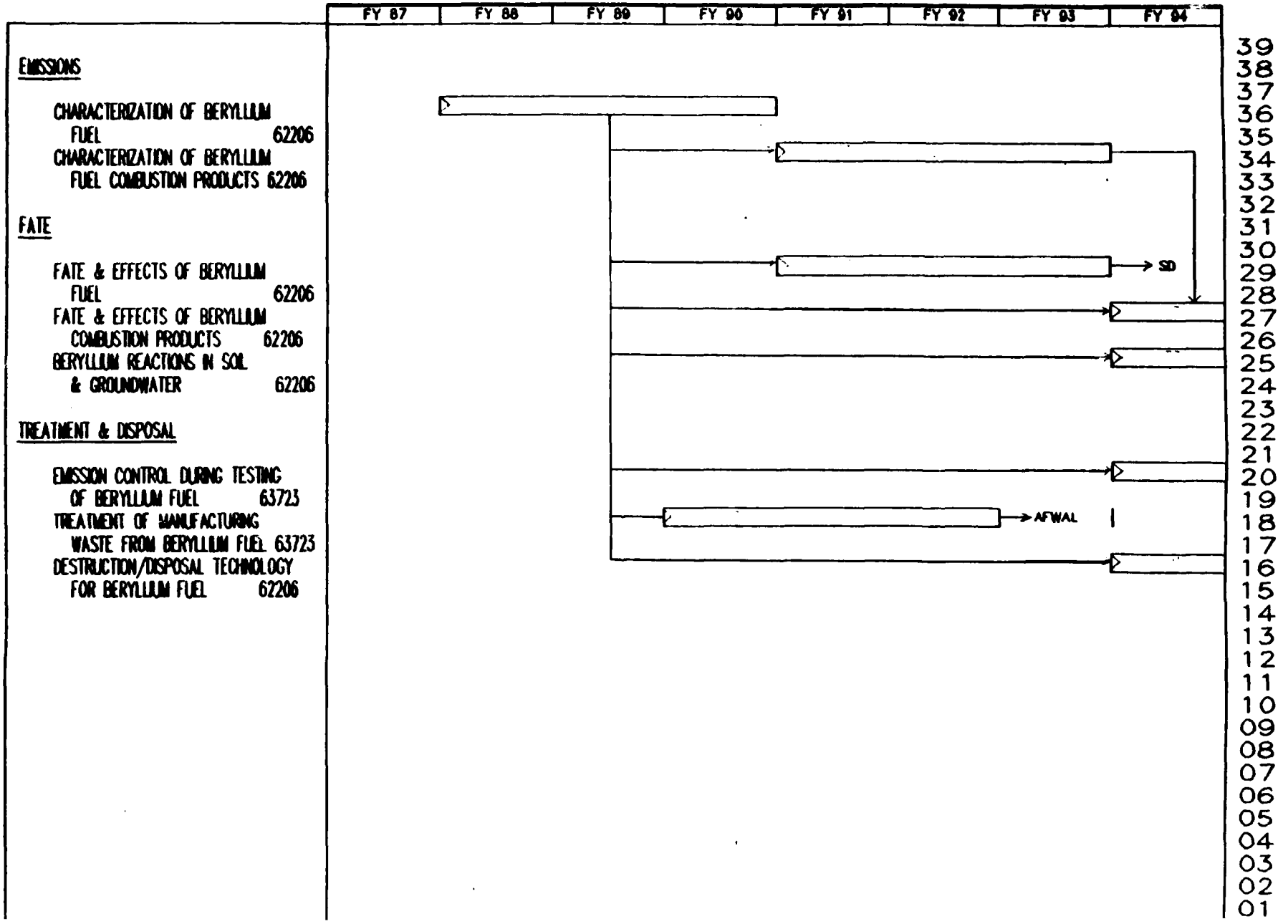
DATE: 24 JULY 1987
ROADMAP: FAVOC-0807q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: BERYLLIUM

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF BERYLLIUM FUEL AND TO DEVELOP CONTROL TECHNOLOGIES TO MINIMIZE THE EVIRONMENTAL IMPACT OF ITS USE BY USAF.

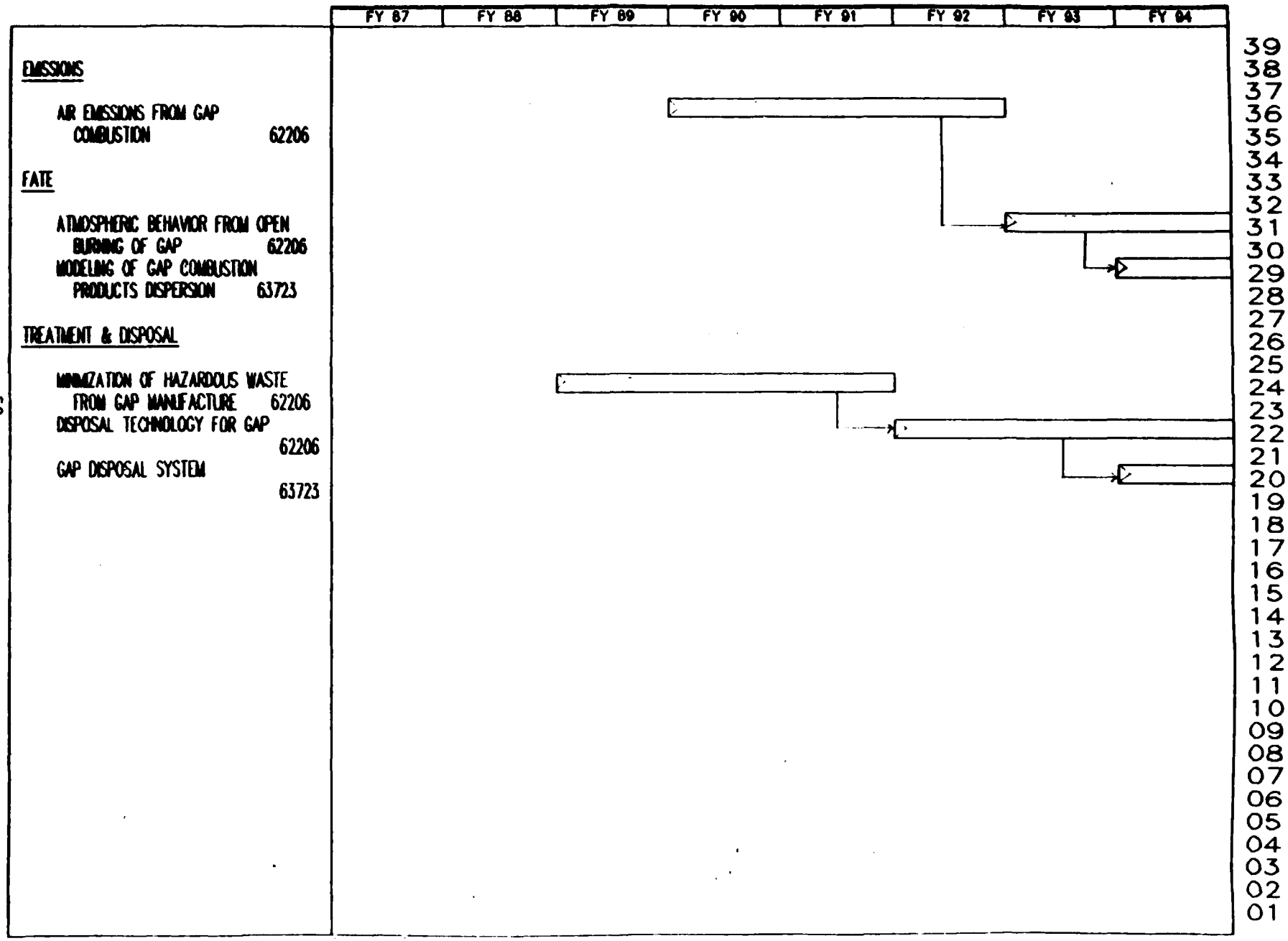
DATE: 24 JULY 1987
ROADMAP: FBBER-0808q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: GLYCIDYL AZIDE POLYMER (GAP)

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF GAP AND TO DEVELOP TECHNOLOGIES TO MINIMIZE THE ENVIRONMENTAL IMPACT OF ITS USE BY USAF.

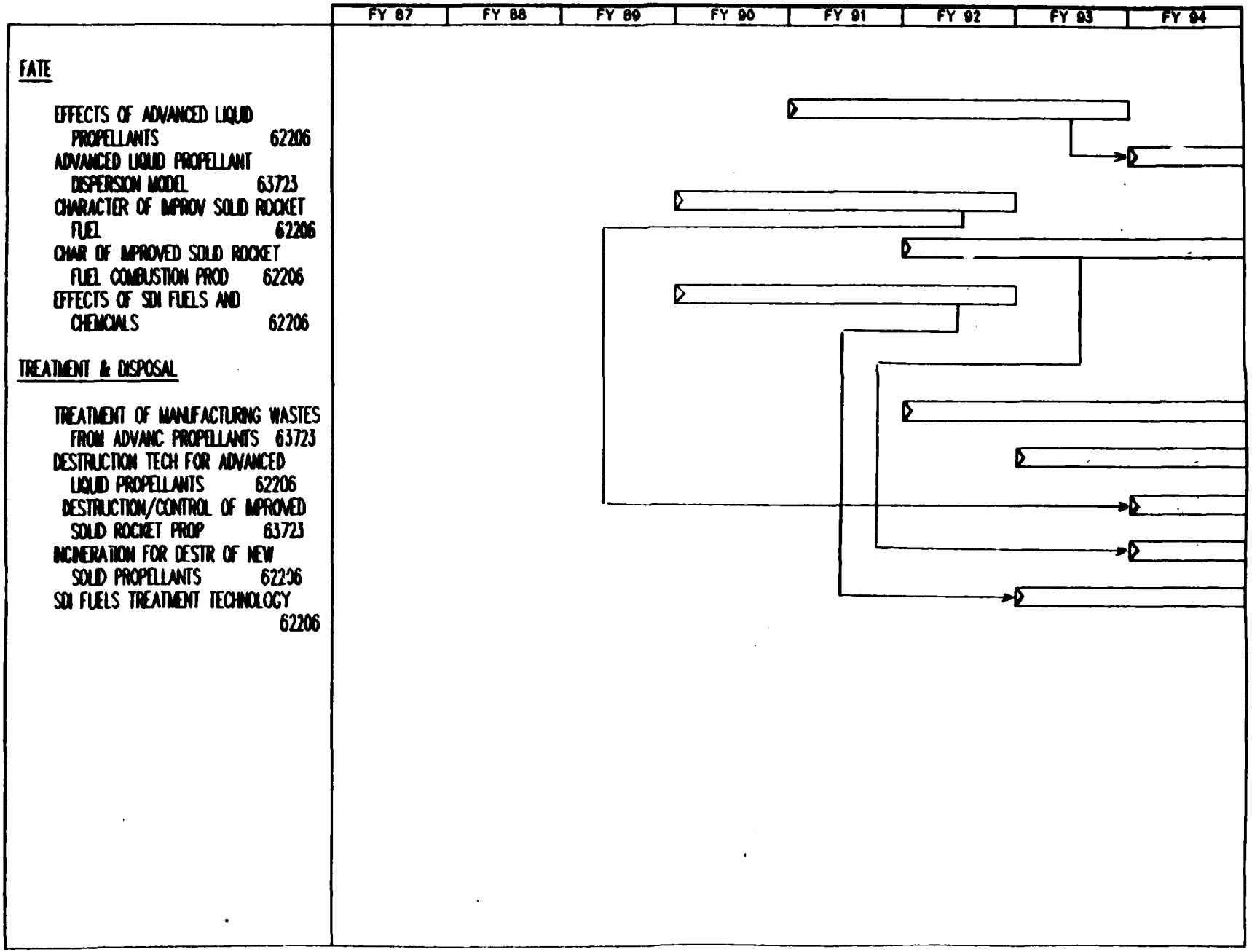
DATE: 24 JULY 1987
ROADMAP: FCGLY-0809q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PERIOD: BASES: FUELS & CHEMICALS
TECH: NEW ROCKET PROPELLANTS (NF2, N2F4, TVOPA)

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF ROCKET PROPELLANTS (OF2, N2F4, TVOPA) AND TO DEVELOP TECHNOLOGIES TO MINIMIZE THEIR ENVIRONMENTAL IMPACT.

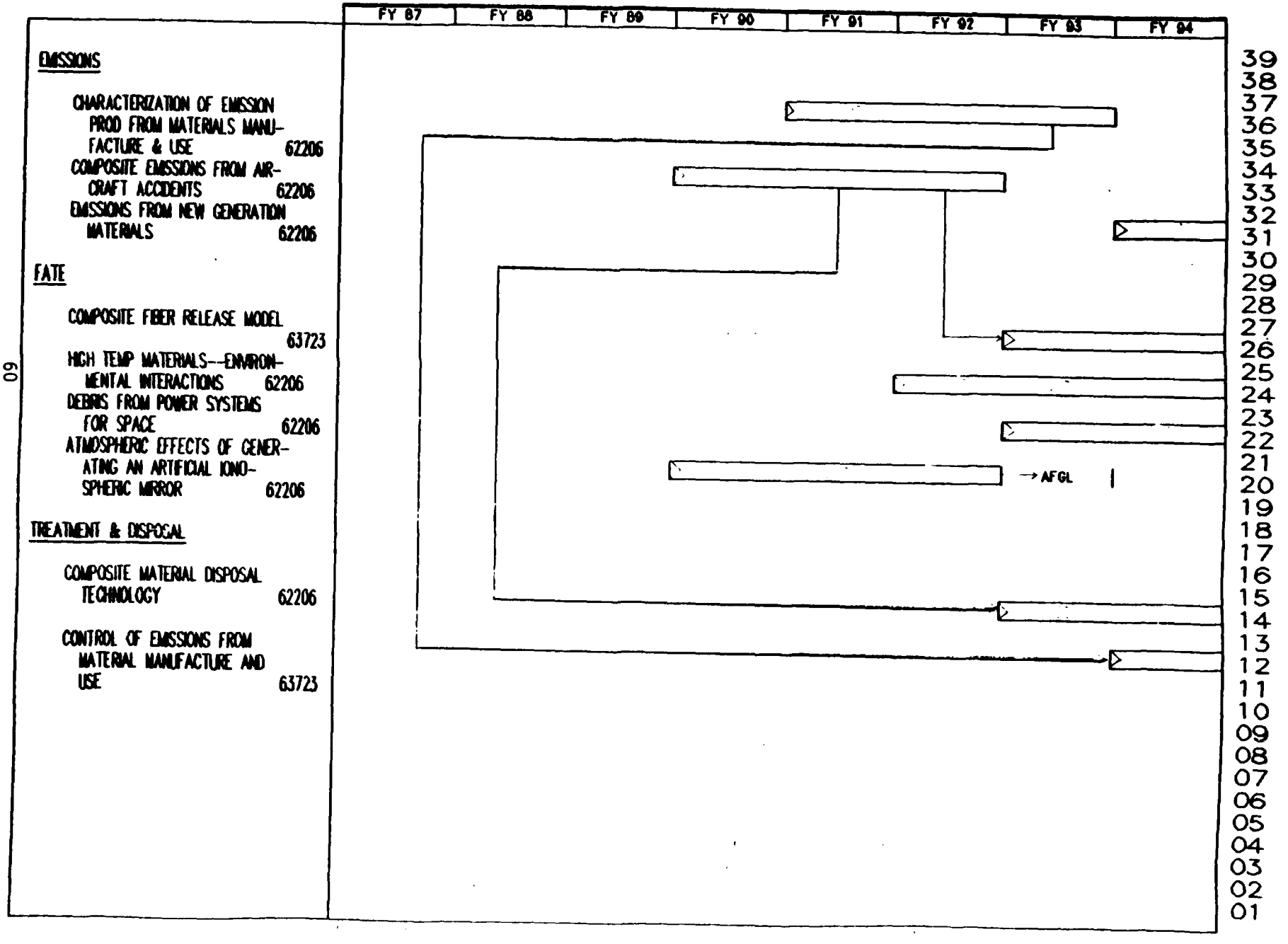
DATE: 24 JULY 1987
ROADMAP: FDNEW-0810q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: NEW MATERIALS

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF NEW USAF MATERIALS AND TO DEVELOP CONTROL TECHNOLOGIES TO MINIMIZE THEIR ENVIRONMENTAL IMPACT.

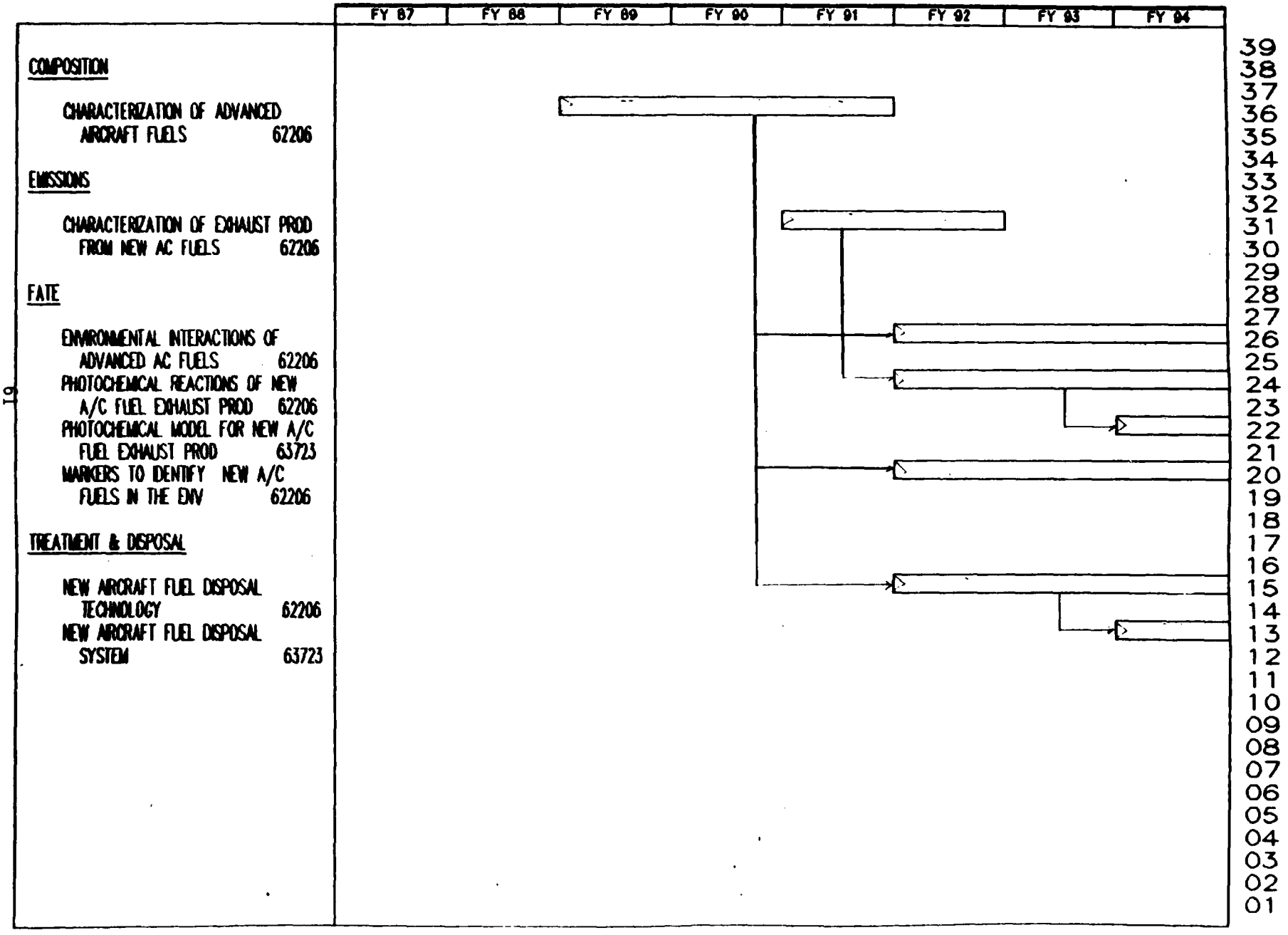
DATE: 24 JULY 1987
ROADMAP: FENEW-0811q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: NEW AIRCRAFT FUELS

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF NEW AIRCRAFT FUELS AND TO DEVELOP CONTROL TECHNOLOGIES TO MINIMIZE THEIR ENVIRONMENTAL IMPACT.

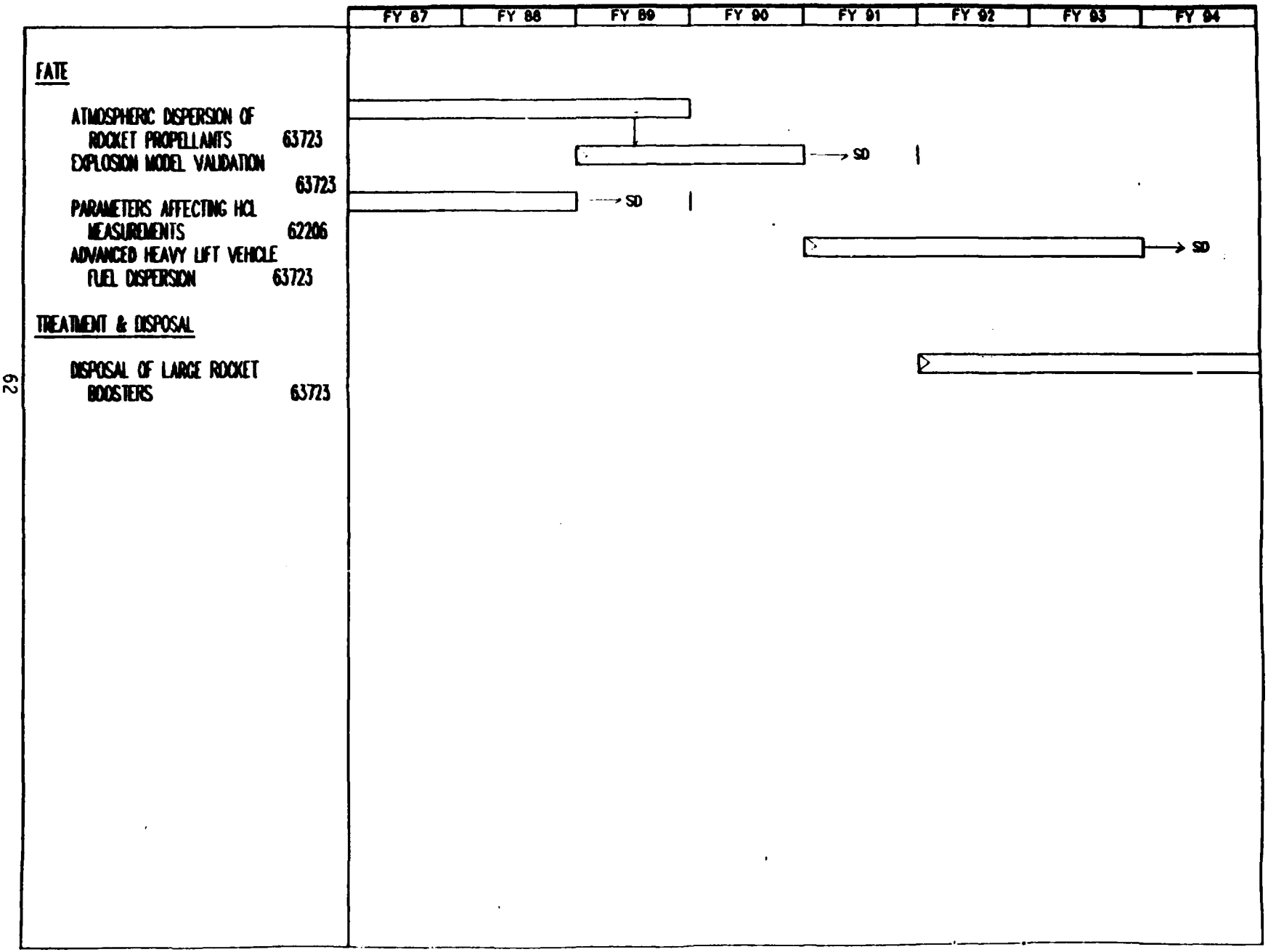
DATE: 24 JULY 1987
ROADMAP: FFNEW-0812q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: AMMONIUM PERCHLORATE PROPELLANT/HCL

GOAL: DEVELOP TECHNOLOGY TO PREDICT HCL TRANSPORT AND FATE IN THE ENVIRONMENT, AND DEVELOP DISPOSAL METHODS FOR SOLID ROCKET PROPELLANTS.

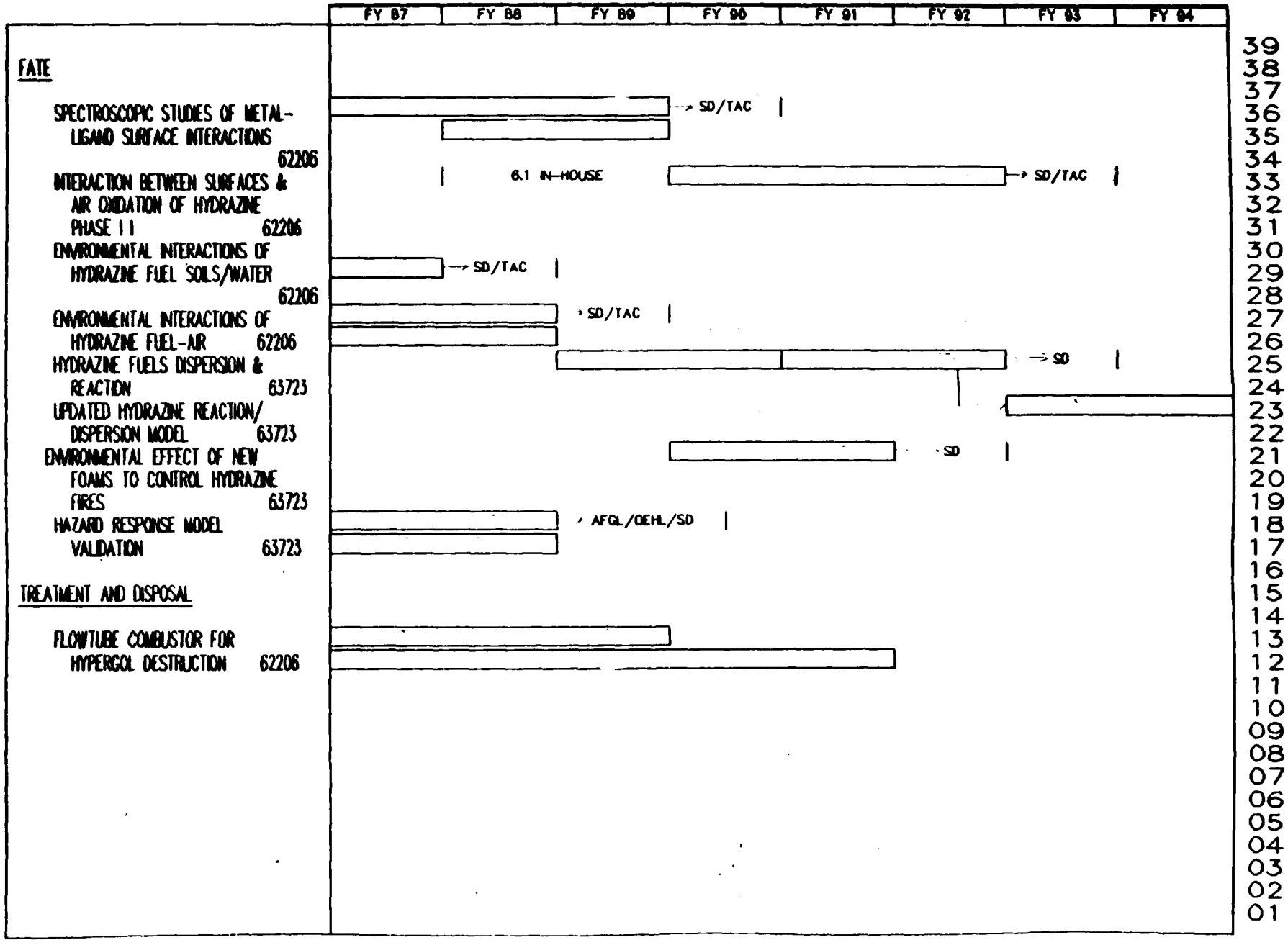
DATE: 24 JULY 1987
ROADMAP: FGAMM-0813q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: HYDRAZINE

GOAL: CHARACTERIZE FATE AND EFFECTS, AND DEVELOP DISPOSAL METHODS FOR HYDRAZINE.

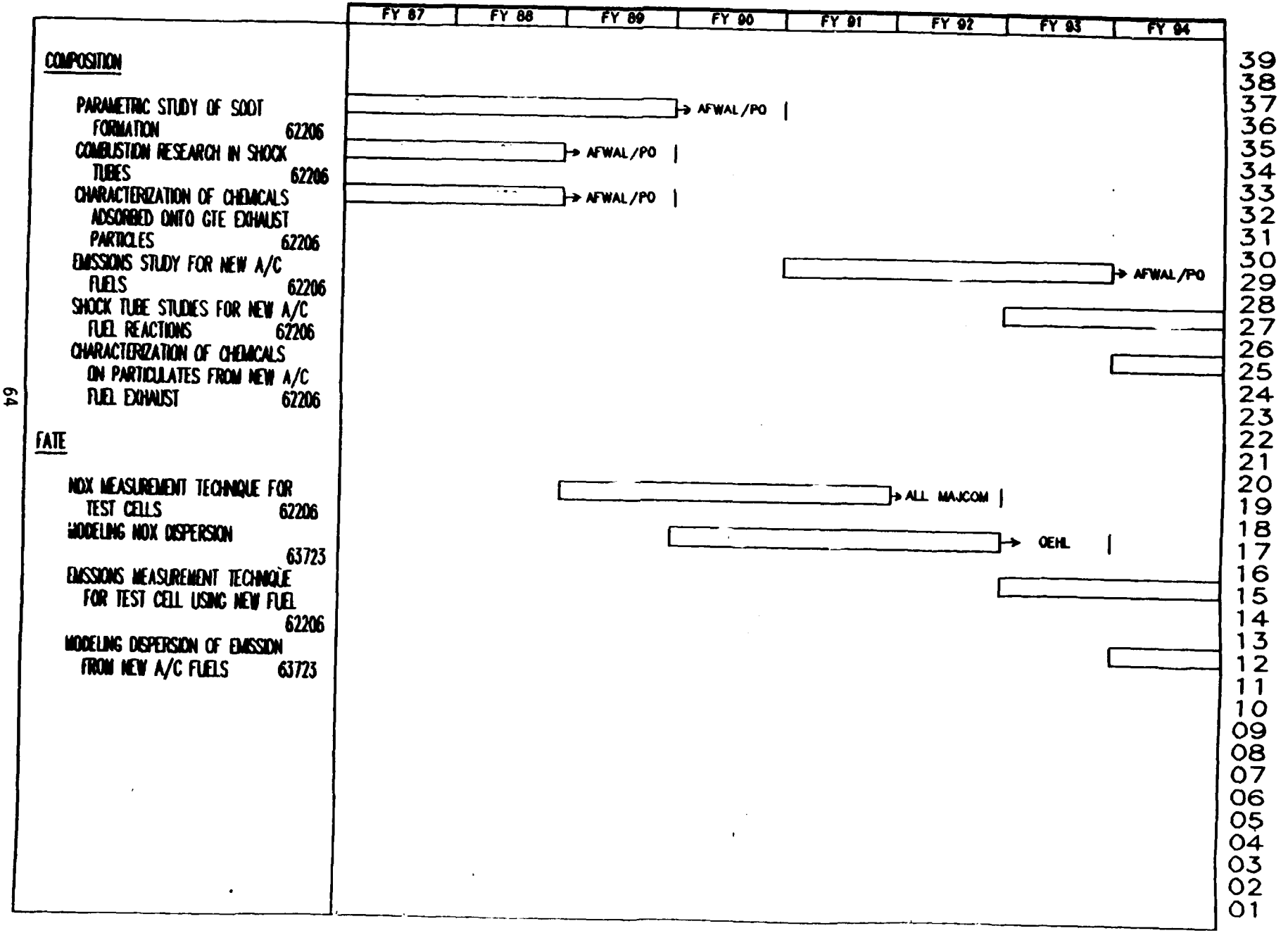
DATE: 24 JULY 1987
ROADMAP: FHHYD-0814q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: AIRCRAFT & TEST CELL EMISSIONS

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF AIRCRAFT AND TEST CELL EMISSIONS AND TO DEVELOP CONTROL TECHNOLOGIES TO MINIMIZE THEIR ENVIRONMENTAL IMPACT.

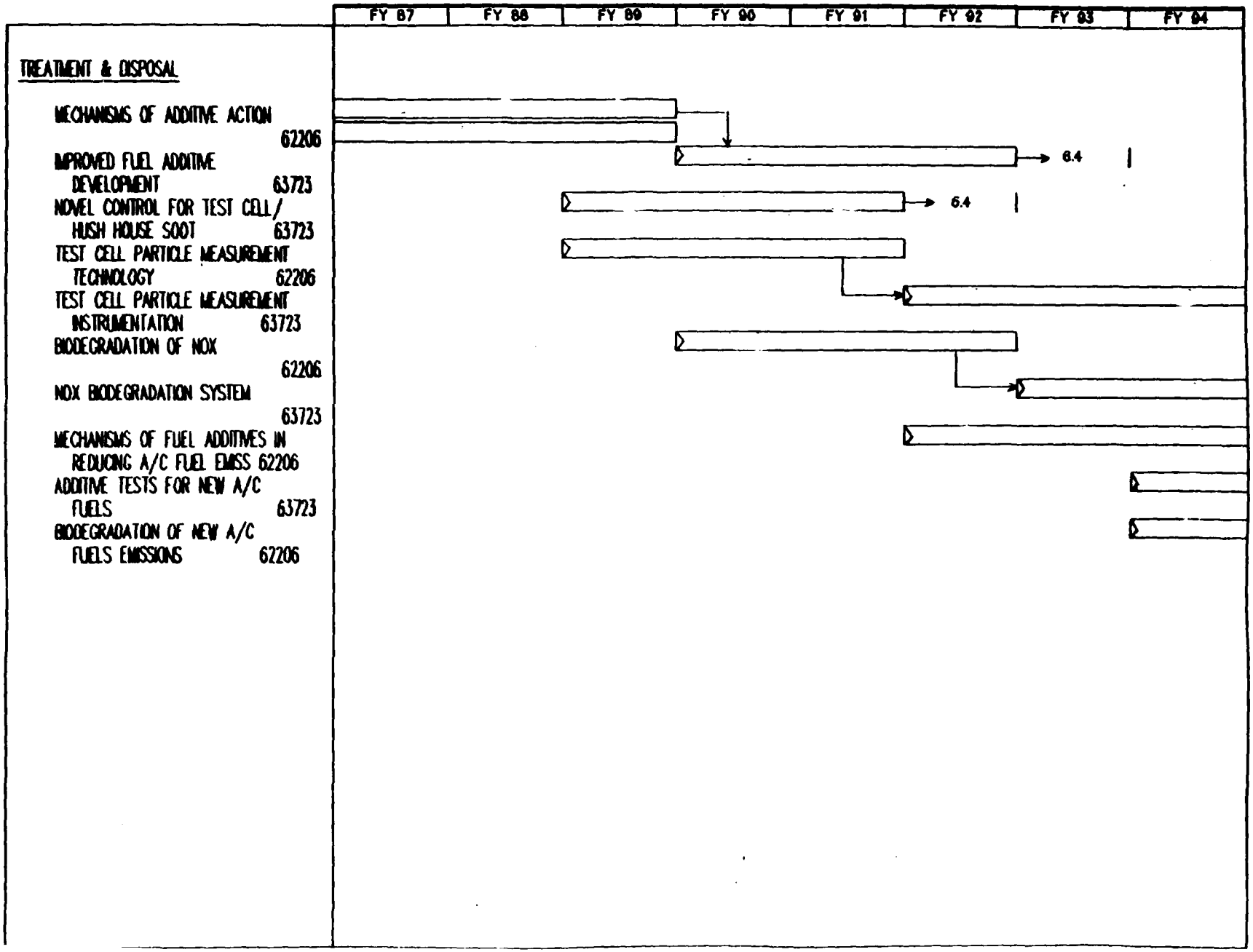
DATE: 24 JULY 1987
ROADMAP: FLAIR-0815q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: AIRCRAFT & TEST CELL EMISSIONS (CONT)

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF AIRCRAFT AND TEST CELL EMISSIONS AND TO DEVELOP CONTROL TECHNOLOGIES TO MINIMIZE THEIR ENVIRONMENTAL IMPACT.

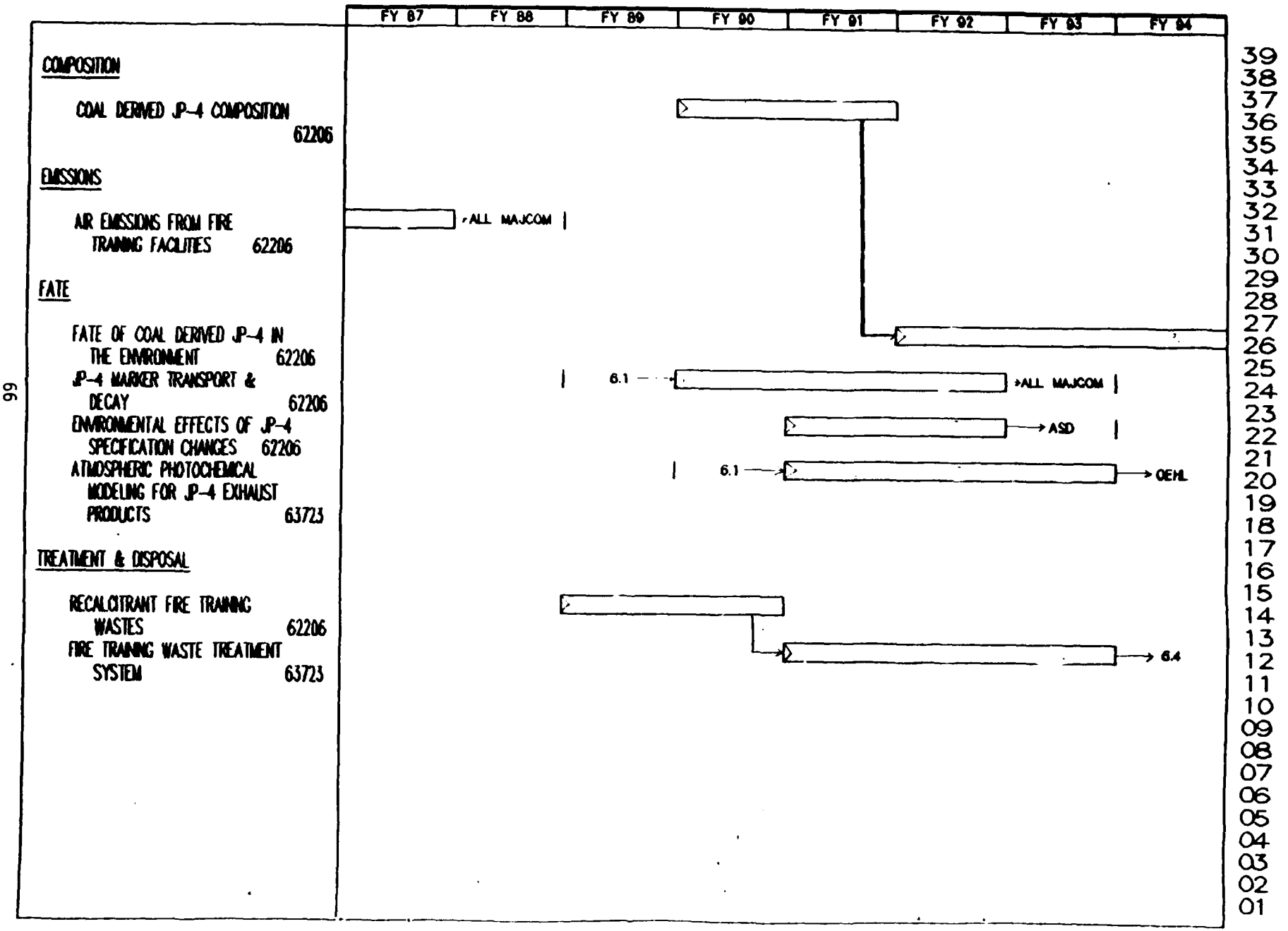
DATE: 24 JULY 1987
ROADMAP: F1AI2-0907q
OPR: AFESC/RD



PROGRAM: AIR BASE OPERABILITY
PRINCIPAL THRUST: FUELS & CHEMICALS
TECH: JP-4

GOAL: TO CHARACTERIZE THE ENVIRONMENTAL FATE AND EFFECTS OF JP-4 AND TO DEVELOP CONTROL TECHNOLOGIES TO MINIMIZE ITS ENVIRONMENTAL IMPACT.

DATE: 24 JULY 1987
ROADMAP: FJP4-0816q
OPR: AFESC/RD



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